DIGI 4 PLUS

USER'S GUIDE

Document No: M4145-1
Second Edition - Rev 3
December 1989

Copyright 1986
Kaye Instruments, Inc.
15 DeAngelo Drive
Bedford, MA 01730 (USA)
Telephone: (617) 275-0300
FAX: (617) 275-9024

WARNING

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. It has been tested and found to comply with the limits for a Class A computing device pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference when operated in a commercial environment. Operation of this equipment in a residential area is likely to cause interference, in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

Although Kaye Instruments has tested and reviewed the material in this manual, Kaye Instruments shall not be held liable for technical or editorial errors and omissions made herein; nor for incidental or consequential damages that may result from the furnishing, performance or use of this manual.

KAYE

The KAYE PROGRAMMER

A Digi 4 Programming Utility

The Programmer is a totally menu-driven software package for configuring Digi 4 and Digi 4 Plus systems. Comprehensive help screens put a built-in programming manual at your finger tips.

Program on-line or off-line. Simply select a programming field and follow the prompts. Integrated data entry screens give you a broad window into your process, letting you see a number of parameters on a single screen. And when you are on-line, you can view real-time process data at the Digi 4 to verify your programming.

```
KAYE DIGI PROGRAMMING UTILITY --- MAIN MENU

SUP - Program Setup                DCF - DIGI Configuration
                                   PWD - Password Definition

ONL - On-line Programming          DAT - Date and Time
            or                     CHN - Channels
OFL - Off-line Programming         CON - System Constants
                                   TMR - System Timers
                                   SCC - System Configuration
                                   TXT - Text Messages
                                   HBF - Historical Buffers
                                   SQC - Sequencer Codes
                                   RLC - Relay Latching Codes
                                   TRN - Auto-Trend

UTL - Utilities                    BKP - Backup DIGI Program
                                   RST - Restore DIGI Program
                                   CMP - Compare DIGI Program
                                   LST - Listing DIGI Backup
                                   DEL - Delete DIGI Backup

Press <F1> for help or <F10> to exit.
SELECT FUNCTION:
```

With The Programmer's utilities, you can back up a program from a Digi 4, load a program file to a Digi 4, and compare a program file with an active Digi 4 program.

Specifications

The Programmer is a stand-alone product. It runs with PC/MS-DOS 2.1 or higher on an IBM or IBM-compatible personal computer. If you are a KVIEW user, The Programmer is included in your software package.

The hardware requirements are:

- 512K RAM
- 10M hard disk drive
- One floppy disk drive
- One serial I/O port (COM1)

Speed, Convenience and Flexibility

The Programmer simplifies the task of configuring the Digi 4. Use it to copy channel, message and other information from one Digi 4 location to another. Two quick keystrokes are all it takes.

Move easily from one programming field to another and back again. On a channel screen, for example, you specify a limit that can trigger a message. Then press a function key and program the message. Another keystroke and you return directly to the channel you were programming to enter additional data.

The Programmer helps you maintain your train of thought; if you're interrupted, you can find your place at a glance, since edited data fields are highlighted until you send them to the Digi 4 or a program file. Press a function key to review all changes made during a programming session.

```
                    CHANNEL PROGRAMMING

Selected DIGI 01
Channel Address: 101

  Function Code: 007                          Unit: P
   Decimal Code: 0.0                         Label: BOILER1

       Source 1: ---                      Source 2: 000
        Input 1: 0.00                      Input 2: 240.00
       Output 1: 0.0                      Output 2: 30.0

  Limit 1 Value: 12.0              Limit 2 Value: 18.0
           Type: H                            Type: H
     Op Code 1: 000000                  Op Code 1: 000000
     Op Code 2: 000000                  Op Code 2: 111000
     Op Code 3: 002224                  Op Code 3: 022325

Description:

Enter 3 digit function code.  Digi will be reprogrammed.
Press <F1> for help, <F9> for menu, or <F10> to exit.
```

A number of Digi 4 functions require more than one channel location. With The Programmer, you can program five channels on one screen. You don't have to rely on memory or handwritten notes; relevant data is right in front of you.

The Programmer also facilitates configuration of trend reports. All the parameters required for trending are grouped together, eliminating chances for error.

KAYE INSTRUMENTS, INC. 15 DE ANGELO DRIVE BEDFORD, MA 01730
TELEPHONE (617) 275-0300 (800) 343-4624 FAX (617) 275-9024 TELEX 6817183

On-line or Off-line

Select On-line Programming to expand a current program without disrupting your measurement and control system. Your entries are immediately error-checked by the Digi 4. You can press a function key to view real-time data from your process and verify that the program is achieving the anticipated results. In On-line mode, you have the option of creating a disk file as you work.

```
                         VIEW DATA

Selected DIGI 01                 Current Digi: Date  11/30/87
                                               Time  13:43:51
Channel    Label     Function   Value    Unit   Alarm  Logic
Address               Code                              Bit
  101      TEMP-1     035       82.0      F     . . .   Off
  102      TEMP-2     035       OPEN      F     . . .   On
  103      TEMP-3     035       83.0      F     . . .   Off
  104      TEMP-4     035       81.6      F     . . .   Off
  105      TEMPAVG    075       82.2      F     . . .   Off
  106      PRESS-1    008       1120.     P     . . .   Off
  107      PRESS-2    008       1200.     P     . . .   Off
  108      PRESS-3    008       1123.     P     . . .   On
  109      PRESS-4    008       1174.     P     . . .   Off
  110      PRESS-5    008       1241.     P     . . .   Off
  111      PRESS-6    008       1095.     P     . . .   Off
  112      COUNTER    060       421       S     . . .   Off
  113      FREQCY1    051       75.92     F     . . .   Off
  114      FREQCY2    051       125.8     F     . . .   Off
  115      FREQCY3    051       137.2     F     . . .   Off
  116      COMPR1     050       OVRNG           . . .   Off

<PgUp>=Previous, <PgDn>=Next,  <Alt><V>=Menu or <F10>=Exit.
```

Select Off-line Programming when you cannot be directly connected to a Digi 4 or when it is more convenient for you to develop a program in your lab or office. Data is sent to the hard disk or a floppy as you program; you can add to or revise the file at any time. The Programmer verifies your entries, field by field. Then use the Restore utility to load the program to a Digi 4.

Help

There are three levels of on-line help: general help for The Programmer and for Digi 4 programming fields, detailed help for each data entry field, and function-specific help available at the Channel screens.

For example, when you request help at the Function Code field, you get an explanation of a function code. Press [PgDn] for a full list of the Digi 4 functions. Then, after you specify a function code for the channel, at any data field you can request help entering the parameters for the selected function.

File Documentation

Description fields let you incorporate documentation into a program as it is developed. Describe key steps or program flow; when you return to the program later on, the descriptions provide a clear explanation of the application.

Documentation is protected when files are updated. While other fields can be overwritten during a backup, the descriptions remain a permanent part of the file unless you edit them.

Utilities

The Backup utility provides convenient and secure program storage on a floppy or hard disk.

```
                BACKUP DIGI PROGRAM UTILITY

DIGI 01                                Today's Date:  11/30/87
Filename: HEATERS                            Time:  09:17:37

Description: _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
             _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
             _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

File    Backup      Program Area                    Progress
Data     Data
 Y        N         Channels                        : . . .
 Y        Y         System Constants                : . . .
 Y        N         System Timers                   : . . .
 Y        N         System Configuration            : . . .
 Y        N         Text Messages                   : . . .
 Y        N         Historical Buffers              : . . .
 Y        N         Sequencer Configuration         : . . .
 Y        N         Relay Latching Configuration    : . . .
 Y        N         CALC Channels (4 Plus)          : . . .

Press <F1> for help, <F8> to start or <F10> to cancel.
```

Use the Restore utility to load a backed up Digi 4 program or a program developed off-line. The structured file format lets you restore an entire program or just selected portions.

The Compare utility automatically compares an active Digi 4 program to a program file and lists all differences, which are identified by program field and location. Use Compare to demonstrate that a program has not been altered during a Restore operation or a specified time period. You can also use Compare to verify that a file is intact before you download it to another Digi 4.

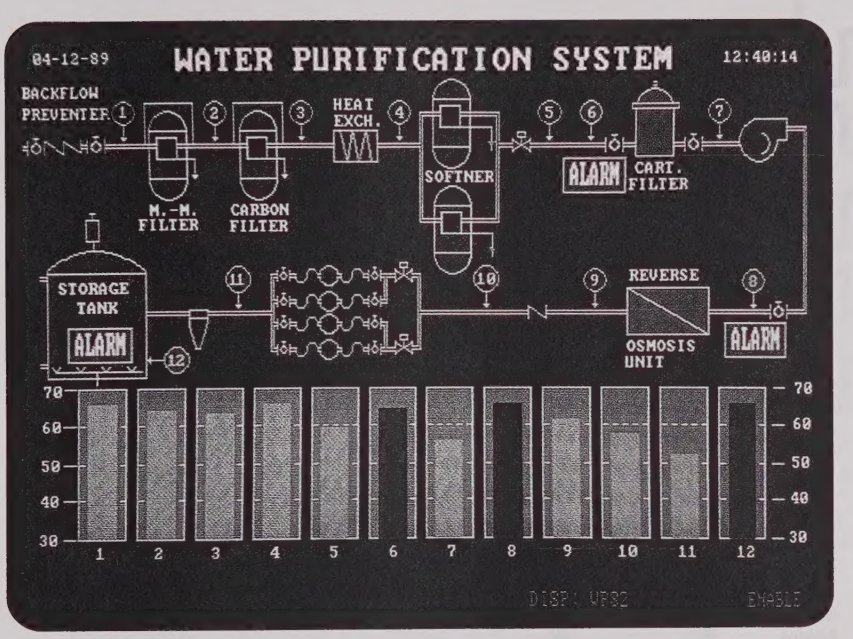
The List Digi Backup utility gives you a hard copy of a Digi 4 program, incorporating any descriptive information you have entered.

KAYE

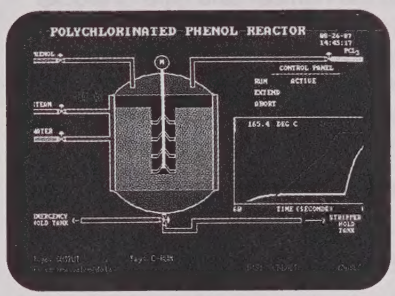
Kaye Instruments, Inc. • 15 De Angelo Drive • Bedford, MA 01730
Telephones (617) 275-0300 • (800) 343-4624
FAX (617) 275-9024 • TELEX 6817183

10M 11/87

Process monitoring at an affordable price



Real-time displays are windows into your process. Graphics, text, numeric values, bar graphs and live trend charts show current conditions and recent trends. Mini-KVIEW gathers historical data for subsequent analysis, and can generate quality control records and production reports.



with Mini-KVIEW.

Kaye Instruments has taken KVIEW, its industry-proven monitoring, analysis and reporting software, and scaled it down to meet the needs of pilot plants and small industrial applications.

Designed specifically to network Kaye data acquisition systems to a PC, Mini-KVIEW provides:

- Dynamic, interactive pixel graphics displays
- On-line monitoring and alarming
- Real-time trending
- Historical data collection and display
- User-definable function keys
- Menu-driven configuration
- Optional report generation

Operator Interface
In a typical application of up to 300 I/O points, the Kaye data acquisition systems handle the primary measurement and analysis, sending data continually to the personal computer. Mini-KVIEW presents the data in real-time, animated full-color displays that give the operator a graphic representation of the process.

Messages at the alarm typer, audible signals, and flashing or color changes indicate alarm conditions. With a single key, the operator can acknowledge alarms or access a display showing the most recent alarm messages.

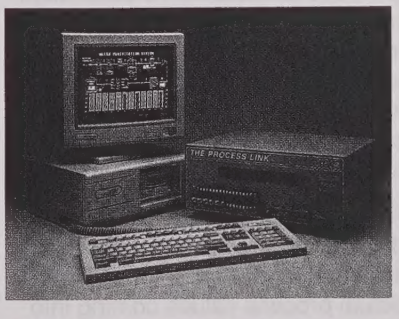
Historical Trends
Mini-KVIEW's Historical Data Collection and Trending feature automatically collects and stores data. With one keystroke, the operator can move from a display to an historical trend, and view the data in trend form.

Reports
With the Report Generator options, you can configure up to 8 reports, each with a different format and different data. Output these reports to a parallel printer or serial device or archive them to the hard disk in spreadsheet format.

With the Archived Data Review option, you can view and print the historical trends and archived reports at an off-line computer or use them with spreadsheets such as Lotus 1-2-3.

Should your application expand beyond Mini-KVIEW's range, you can easily upgrade to KVIEW without losing previous work.

Now that you're ready to move to PC-based process monitoring, choose the system that best meets your needs *and* your budget: Mini-KVIEW.



Combine Mini-KVIEW with the Kaye Process Link for monitoring and analysis at a fraction of the cost of comparable systems.

KAYE

Configuration

You don't need computer programming knowledge to configure Mini-KVIEW. Menus, prompts and on-line help guide you through every step.

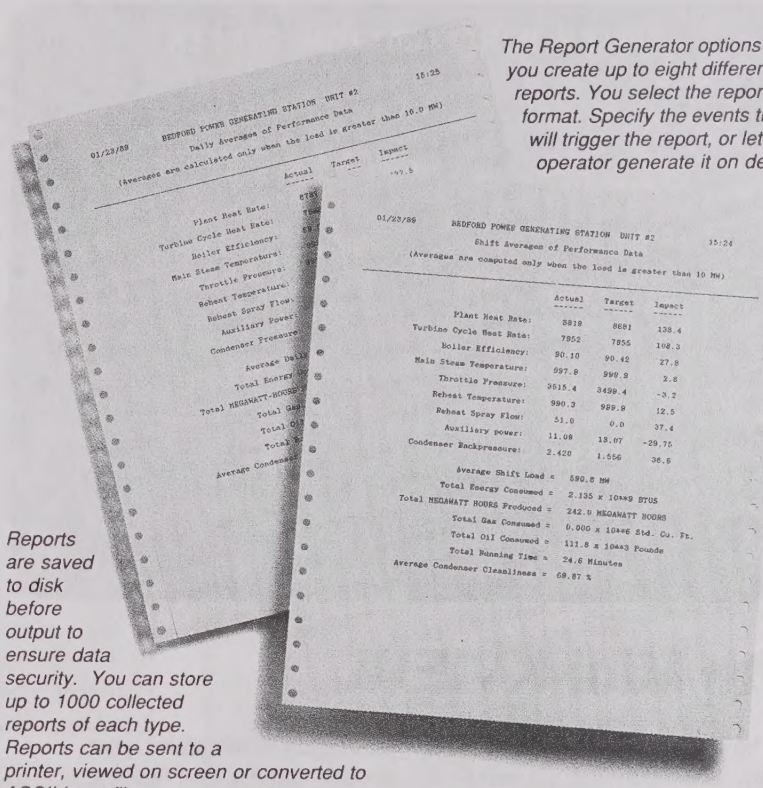
The program has three preconfigured database structures, varying in the number and type of blocks (see box). The first database is appropriate for general applications, the second for monitoring, and the third for applications requiring more discrete I/O.

	DATABASE		
Block Type	1	2	3
Analog Input	150	260	100
Analog Output	50	25	50
Digital Input	50	50	100
Digital Output	50	10	50
Display I/O	50	10	75
Boolean	50	10	100
Calculation	150	150	100
Trend	100	100	80
Signal Select	20	20	50
Dead Time	50	50	40

Drawing Displays

The Mini-KVIEW package includes a mouse for building 16-color, high resolution displays. You can move images from one part of the screen to another, change colors, make images larger or smaller, and create a library of subpictures for future use.

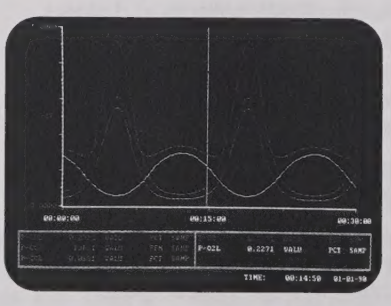
A set of menus helps you link the display to the database. It is the links that let the operator see actual process values coming into Mini-KVIEW. The links also show data generated by Mini-KVIEW, such as calculations and trends, and let the operator, under password control, enter new values and change process conditions.



The Report Generator options let you create up to eight different reports. You select the report format. Specify the events that will trigger the report, or let the operator generate it on demand.

Reports are saved to disk before output to ensure data security. You can store up to 1000 collected reports of each type. Reports can be sent to a printer, viewed on screen or converted to ASCII input files.

You can create a function-specific operator keyboard. For example, you can build macros that let the operator select a new display or generate a report with just one keystroke.



With the Historical Data program, you select up to 150 points to be collected at sample frequencies ranging from once every 2 seconds to once an hour. You can view up to 8 variables at a time in a trend graph.

Mini-KVIEW includes *The Programmer,* a software package for programming Kaye's Digistrip 4, Digi-Link 4 and Process Link data acquisition systems.

Minimum Hardware Requirements

- IBM PC/AT, PS/2 Model 50 and above, Compaq 386, or 100% compatible
- 640K bytes system memory
- 256K bytes extended memory
- 10M byte hard disk
- $3^1/_2$" (720K byte or 1.44M byte) or $5^1/_4$" (360K byte or 1.2M byte) floppy disk drive
- EGA or VGA adapter with appropriate color monitor
- One parallel and one serial port

Kaye Instruments, Inc.
800-343-4624

15 DeAngelo Drive
617-275-0300

Bedford, MA 01730-9990
FAX 617-275-9024

PDS 501A 5M October 1989

KAYE

KAYE

KAYE

Accessory for Asset

933771

1-800-GE-RENTS

DIGI 4 PLUS USER'S GUIDE

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_07803

KAYE

Dear Customer:

Thank you for purchasing a Kaye Instruments data acquisition product. This equipment has been thoroughly tested and calibrated prior to shipment. As a valued customer, we want you to know that our commitment to you is an extended one, and that Kaye personnel and services are available to help make your application a success.

To help acquaint customers with our equipment, we conduct an extensive 4-day training program. The classes are hands-on oriented and explain the operation, programming and calibration of a Digi 4 Plus. The 1990 training programs will be held January 16-19, March 13-16, May 8-11 and September 11-14.

We also offer a VHS training tape called Digi 4 Basic Training. It uses hands-on exercises and animated graphics to illustrate basic Digi programming concepts.

The Kaye Programming Utility is available for configuring the Digi 4 Plus on-line or off-line. It is a PC-DOS based software package that runs on an IBM or compatible personal computer.

Our field service representatives are available for on-site start-up assistance. Our technical support and applications engineering groups in Bedford are available to answer specific equipment questions and generate complete applications programs.

We hope you will use these services as they meet your needs. In this regard, please feel free to contact us in Bedford.

For application or service assistance, please call 800-343-4624 or 617-275-0300.

Sincerely,

Newell Tillman

Newell Tillman
Customer Service Manager

Kaye Instruments, Inc. • 15 De Angelo Drive • Bedford, MA 01730
Telephone (617) 275-0300 • (800) 343-4624 • Fax (617) 275-9024

TABLE OF CONTENTS

SECTION 1 - SYSTEM OVERVIEW

1.1 SYSTEM DESCRIPTION 1-1

1.2 OPERATION 1-3
1.2.1 Inputs 1-3
1.2.2 Processing 1-4
1.2.3 Output 1-6

1.3 GETTING STARTED 1-9

SECTION 2 - INSTALLATION

2.1 GENERAL INFORMATION 2-1

2.2 INSTALLING A DIGISTRIP 4 PLUS 2-1
2.2.1 Connecting Peripherals 2-4
2.2.2 Connecting Analog Inputs 2-10
2.2.3 Connecting Status Inputs 2-15
2.2.4 Initializing the System 2-16
2.2.5 Setting the System Clock 2-17
2.2.6 Loading Paper 2-18
2.2.7 Test Mode 2-19

2.3 INSTALLING A DIGI-LINK 4 PLUS 2-20
2.3.1 Connecting Peripherals 2-22
2.3.2 Connecting Analog Inputs 2-22
2.3.3 Connecting Status Inputs 2-22
2.3.4 Initializing the System 2-23
2.3.5 Setting the system clock 2-23

SECTION 3 - OPERATOR PANEL

3.1 GENERAL INFORMATION 3-1

3.2 KEYS 3-1

3.3 DISPLAYS AND INDICATOR LIGHTS 3-4

3.4 LIST PROGRAM 3-5

SECTION 4 - CHANNEL ASSIGNMENTS

4.1 GENERAL INFORMATION 4-1

4.2 CHANNEL OUTPUT DATA 4-2

4.3 CHANNEL ASSIGNMENTS 4-4
4.3.1 Function and Decimal Codes 4-4
4.3.2 Sources 4-5
4.3.3 Input and Output Values 4-7
4.3.4 Limits 4-9
4.3.5 Limit Operation Codes 4-10
4.3.6 Engineering Units 4-10
4.3.7 Labels 4-10

4.4 OUTPUTTING A CONSTANT 4-11

4.5 COPYING ASSIGNMENTS 4-11

SECTION 5 - FUNCTIONS

5.1 GENERAL INFORMATION 5-1

5.2 SKIP FUNCTION (000) 5-2

5.3 SYSTEM INPUT FUNCTIONS (001-050) 5-3
5.3.1 Voltage Functions (001-005) 5-9
5.3.2 Linear Input Functions (006-017) 5-10
5.3.3 Thermocouple Functions (018-038) 5-20
5.3.4 RTD Functions (039-046) 5-22
5.3.5 Multi-Segment Input Functions (047-050) 5-23

5.4 LINEAR TRANSFER FUNCTIONS (051-053) 5-25

5.5 MULTI-SEGMENT TRANSFER FUNCTION (054) 5-28

5.6 DATA ACCUMULATION FUNCTIONS (055-058) 5-29

5.7 METER FUNCTION (059) 5-34

5.8 COUNTER FUNCTION (060) 5-36

5.9 INTERVAL FUNCTIONS (061-064) 5-37

5.10 ELAPSED TIMER FUNCTIONS (065-066) 5-40

5.11 HISTORICAL BUFFER FUNCTIONS (067-074) 5-42

5.12 GROUP FUNCTIONS (075-081) 5-44

5.13 PAIR FUNCTIONS (082-083) 5-46

5.14 MATH FUNCTIONS (084-098) 5-47

5.15 POLYNOMIAL TRANSFER FUNCTION (099) 5-48

5.16 OPTIONAL DATA STORAGE FUNCTION (100) 5-50

5.17 BOOLEAN FUNCTIONS (101-107) 5-51

5.18 FLIP FLOP FUNCTIONS (108-111) 5-54

5.19 DATA COMPARE FUNCTIONS (112-113) 5-57

5.20 DATA TRANSFER FUNCTIONS (114-115) 5-58

5.21 DATA SELECT FUNCTIONS (116-120) 5-61

5.22 INTEGER ENCODER FUNCTIONS (121-122) 5-63

5.23 CONTROL COUNTER FUNCTION (123) 5-65

5.24 CONTROL TIMER FUNCTIONS (124-127) 5-66

5.25 INDIRECT TRANSFER FUNCTION (128) 5-68

5.26 LOGICAL TRANSFER/LOAD DATA VALUE FUNCTION (129) 5-71

5.27 APPLICATION FIRMWARE FUNCTIONS (130-133) 5-72
5.27.1 Relative Humidity Function (130) 5-73
5.27.2 Cylindrical Tank Volume Function (131) 5-74
5.27.3 Spherical Tank Volume Function (132) 5-75
5.27.4 Lethality Rate Function (133) 5-76

5.28 CONTROL FIRMWARE FUNCTIONS (140-150) 5-78
5.28.1 Proportional Control/External Reset Functions (140-141) 5-79
5.28.2 Standard PID Functions (142-143) 5-80
5.28.3 Batch Preload PID Functions (144-145) 5-81
5.28.4 Cascade PID Functions (146-147) 5-82
5.28.5 Auto Manual Track and Hold Function (148) 5-83
5.28.6 Auto Manual Track and Hold Function (149) 5-84
5.28.7 Sequencer Function (150) 5-85

5.29 APPLICATION FIRMWARE FUNCTIONS (160-195) 5-86
5.29.1 Weighted Mixture Function (160) 5-87
5.29.2 Specific Volume of a Perfect Gas Function (161) 5-89
5.28.3 Specific Volume of Natural Gas Function (162) 5-92
5.29.4 Specific Volume of Steam Functions (163 and 165) 5-94
5.29.5 Enthalpy of Steam Functions (164 and 166) 5-95
5.29.6 Specific Volume/Higher Value of Natural Gas Mixtures Function (167) . . . 5-96
5.29.7 Orifice Flow Functions (170-174) 5-99
5.29.8 Compressor Efficiency Function (175) 5-102
5.29.9 Orifice Flow/Upstream Pressure Tap Function (176) 5-104
5.29.10 Flow Nozzle Function (177) 5-106
5.29.11 Venturi Meter Function (178) 5-108
5.29.12 Saturation Pressure of Steam Functions (180-181) 5-110
5.29.13 Saturation Temperature of Steam Functions (182-183) 5-111
5.29.14 Entropy of Steam Functions (184-185) 5-112
5.29.15 Specific Volume of Water Functions (186-187) 5-113
5.29.16 Enthalpy of Water Functions (188-189) 5-114
5.29.17 Entropy of Water Functions (190-191) 5-115
5.29.18 Isentropic Efficiency of Turbine Stage Functions (192-193) 5-116
5.29.19 Exhaust Quality/Enthalpy of Turbine Stage Functions (194-195) 5-117

5.30 ZERO OFFSET FUNCTION (199) 5-118

5.31 AUTOMATIC DATA STORAGE FUNCTIONS (201-209 and 211) 5-120

SECTION 6 - SOURCES

6.1 GENERAL INFORMATION 6-1

6.2 SYSTEM INPUT DATA 6-1

6.3 NUMERICAL INPUT DATA 6-2
6.3.1 Channels (101-816) and CALC Channels (001-099) 6-2
6.3.2 Global System Parameters (901-916) 6-3
6.3.3 Constants (01-99) 6-6

6.4 LOGICAL INPUT DATA 6-7

6.5 SYSTEM TIMERS 6-11

SECTION 7 - LIMITS, LIMIT OP-CODES AND RELAYS

7.1 GENERAL INFORMATION 7-1

7.2 LIMITS 7-1
7.1.1 High and Low Limits 7-1
7.1.2 Rate-of-Change Limit 7-1

7.3 LIMIT OP-CODES 7-3
7.3.1 Limit Op-Code 1 7-5
7.3.2 Limit Op-Code 2 7-6
7.3.3 Limit Op-Code 3 7-8

7.4 RELAYS 7-9
7.4.1 Logical Relays 7-9
7.4.2 Master Relays 7-9
7.4.3 Watchdog Relay 7-11
7.4.4 Optional Physical Relays 7-11

SECTION 8 - MESSAGES AND LABELS

8.1 GENERAL INFORMATION 8-1

8.2 ANSWER-BACK MESSAGE (00) 8-2

8.3 MULTI-PURPOSE MESSAGES (01-99) 8-3
8.3.1 Limit Messages 8-3
8.3.2 Sequencer Messages 8-4
8.3.3 Header Messages 8-4
8.3.4 Auto-Dial Telephone Numbers (Optional Modem Equipment) 8-4
8.3.5 Start Text and End Text Messages 8-4

8.4 CHANNEL LABELS 8-6

SECTION 9 - REPORTS

9.1 GENERAL INFORMATION 9-1

9.2 REPORT GENERATION 9-2

9.3 REPORT FORMATS 9-3
9.3.1 Headers 9-3
9.3.2 Body 9-4
9.3.3 Sample Reports 9-6

9.4 TEXT OUTPUT BUFFER 9-9

SECTION 10 - CONFIGURATION CODES

10.1 GENERAL INFORMATION 10-1

10.2 SYSTEM CONFIGURATION CODES 10-2
Scanner Mapping (001) 10-5
Scanner Mapping (002) 10-7
Peripheral Ports (003) 10-8
Printer Port (004) 10-10
Communications Port (005) 10-11
European Formats (006) 10-12
Master Relays (007) 10-13
Security (009) 10-14
Data Report Configuration Codes (010-047) 10-16
Generate Report (010, 020, 030, and 040) 10-17
Release Buffered Reports (011, 021, 031, and 041) 10-18
Define Buffering/Output Device (012, 022, 032, and 042) 10-19
Auto-Dial, STX, ETX (013, 023, 033, and 043) 10-20
Format Header (014, 024, 034, and 044) 10-21
Format Report (015, 025, 035, and 045) 10-22
Select Data (016, 026, 036, and 046) 10-24
Select Historical Buffer (017, 027, 037, and 047) 10-26
Alarm Status Report Configuration Codes (050-056) 10-28
Generate Report (050) 10-29
Release Buffered Report (051) 10-30
Define Buffering/Output Device (052) 10-31
Auto-Dial, STX, ETX (053) 10-32
Format Header (054) 10-33
Format Report (055) 10-34
Select Data (056) 10-36
Message Configuration Codes (061-063) 10-37
Release Buffered Messages (061) 10-38
Define Buffering/Output Device (062) 10-39
Auto-Dial, STX, ETX (063) 10-40
Accumulation Total Configuration Codes (071-073) 10-41
Release Buffered Totals (071) 10-42
Define Buffering/Output Device (072) 10-43
Auto-Dial, STX, ETX (073) 10-44
Programming Mode Password (901) 10-45
CXT Mode Password (902) 10-46

10.3 RELAY LATCHING CONFIGURATION CODES (101-148) 10-47

10.4 SEQUENCER CONFIGURATION CODES (201-299) 10-48

SECTION 11 - COMMUNICATIONS PORT

11.1 GENERAL INFORMATION 11-1

11.2 TRM PROTOCOL 11-3
11.2.1 Defining TRM Operation 11-3
11.2.2 Auto-Dial 11-4
11.2.3 TRM Transmissions 11-7

11.3 CXT PROTOCOL 11-8
11.3.1 Defining CXT Protocol 11-8
11.3.2 CXT Communications 11-11
11.3.3 Error Handling 11-20
11.3.4 CXT Commands and Responses Tables 11-22

LIST OF FIGURES

Figure 1-1. System Operation 1-3
Figure 1-2. Channel Matrix and Channel Parameters 1-5
Figure 1-3. CALC Channel Parameters 1-5
Figure 1-4. System Block Diagram 1-5

Figure 2-1. Digistrip 4 Plus Front View 2-2
Figure 2-2. Digistrip 4 Plus Rear View 2-2
Figure 2-3. Digistrip 4 Plus Rear View with Expander Box 2-3
Figure 2-4. Digistrip 4 Plus Right Side of Chassis 2-3
Figure 2-5. Digistrip 4 Plus Left Side of Chassis 2-4
Figure 2-6. Interface I/O Panel 2-4
Figure 2-7. RD-48/AO-16 Connections (PID Control) 2-8
Figure 2-8. DS-8 and/or FS-8 Connections (Port 1) 2-8
Figure 2-9. DS-8 and/or FS-8 Connections (Port 1 and Port 2) 2-9
Figure 2-10. AO-16 Connections (No PID Control) 2-10
Figure 2-11. Analog Plus Scanner Terminals 2-11
Figure 2-12. Voltage Transducer Connections 2-11
Figure 2-13. VD-100/Voltage Transducer Connections 2-11
Figure 2-14. Current Transmitter Connections 2-12
Figure 2-15. Thermocouple/Analog Plus Scanner Connections 2-13
Figure 2-16. Thermocouple/Automatic Ice Point Reference Connections 2-14
Figure 2-17. Thermocouple/Uniform Temperature Reference Connections 2-14
Figure 2-18. RTD Plus Scanner Connections 2-15
Figure 2-19. Status Input Connections 2-16
Figure 2-20. Digistrip 4 Plus Printer 2-19
Figure 2-21. Sample Test Mode Printout 2-19
Figure 2-22. Digi-Link 4 Plus in Standard NEMA Enclosure 2-21
Figure 2-23. Digi-Link 4 Plus Display and Interface Panels 2-21
Figure 2-24. Digi-Link 4 Plus Fully Populated 2-22

Figure 3-1. Digi 4 Plus Operator Panel 3-1
Figure 3-2. Displays and Indicator Lights 3-4
Figure 3-3. Channel Parameter Listing 3-7
Figure 3-4. Configuration Code Listing 3-8
Figure 3-5. Constant Listing 3-9
Figure 3-6. Messages Listing 3-10
Figure 3-7. System Timer Listing 3-11
Figure 3-8. Historical Buffer Listing 3-12
Figure 3-9. Relay Latch States Listing 3-13
Figure 3-10. Sequencer Parameter Listing 3-14

Figure 4.1. Channel Matrix 4-1
Figure 4-2. Parameters 4-2

Figure 5-1. System Input Functions 5-3
Figure 5-2. Effects of Filtering on Output Data 5-5
Figure 5-3. Assigning Calibration Points 5-6
Figure 5-4. Two Point Calibration 5-6
Figure 5-5. Single Point Calibration 5-6
Figure 5-6. Calculating the Offset 5-7
Figure 5-7. Calculating the Slope of a Linear Input Function 5-10
Figure 5-8. Linear Input Functions 5-12
Figure 5-9. Unbounded and Clamped Linear Input Functions 5-15

Figure 5-10. Bounded Linear Input Functions 5-15
Figure 5-11. Boolean Functions 5-51

Figure 7-1. Sample Rate of Change Limit 7-2
Figure 7-2. How Digi 4 Plus Monitors Limits 7-3
Figure 7-3. Limit Op-Code 1 7-5
Figure 7-4. Limit Op-Code 2 7-7
Figure 7-5. Limit Op-Code 3 7-8
Figure 7-6. Trip Action 7-9

Figure 9-1. Sample Data Report 1 9-6
Figure 9-2. Sample Data Report 2 9-7
Figure 9-3. Sample Data Report 3 9-7
Figure 9-4. Sample Data Report 4 9-8
Figure 9-5. Sample Alarm Status Report 9-8

Figure 11-1. Interface I/O Panel COMM Ports 11-1
Figure 11-2. Current Loop Connections 11-1
Figure 11-3. Command Message Format 11-12
Figure 11-4. Response Message Format 11-12
Figure 11-5. Instruction Field Format 11-13
Figure 11-6. Broadcast Command Format 11-15
Figure 11-7. Reply Field Format 11-16

LIST OF TABLES

Table 1-1. Model 4C, 4M and 4S Functions 1-2

Table 2-1. Digistrip 4 Plus Scanner Combinations 2-1
Table 2-2. Digi 4 Plus Peripheral Connections 2-5
Table 2-4. Shunt Resistor Guide 2-12
Table 2-5. Scanners in Standard NEMA 4 2-20

Table 4-1. Sources 4-6

Table 5-1. Accumulation Output Ranges 5-31
Table 5-2. Boolean Operators 5-52
Table 5-3. Flip Flop Functions 5-55
Table 5-4. Universal Gas Constants and Selected Specific Gas Constants 5-90
Table 5-5. Function Code 167 Channel Assignments 5-97
Table 5-6. Function Code 175 Summary 5-103
Table 5-7. Function Code 176 Output 2 Values 5-105
Table 5-8. Function Code 177 Output 2 Values 5-107
Table 5-9. Function Code 178 Output 2 Values 5-109

Table 6-1. Sources 6-1
Table 6-2. Global System Parameters 6-3
Table 6-3. Contents of Historical Buffer 06 6-5
Table 6-4. Logic Addresses 6-8

Table 7-1. Limit Op-Codes 7-10
Table 7-2. Digits 1 and 2 of Configuration Code Address 007 7-10

Table 8-1. Text Addresses 8-1

Table 9-1. Bytes in the Text Output Buffer 9-12

Table 11-1. COMM Port RS 232 C Modem Support Circuits 11-2
Table 11-2. COMM Port Baud Rate 11-3
Table 11-3. Sample Auto Dial Phone Numbers 11-5
Table 11-4. Instruction Field Values 11-7
Table 11-5. COMM Port Baud Rate 11-9
Table 11-6. Unit Identifier 11-10
Table 11-7. Command Classes 11-13
Table 11-8. Response Classes and Response Class Codes 11-17
Table 11-9. Data Return Responses (Reply Field) 11-17
Table 11-10. Text Output Responses (Reply Field) 11-17
Table 11-11. Execution Responses (Reply Field) 11-17
Table 11-12. System Status Responses (Reply Field) 11-18
Table 11-13. CXT Commands and Responses 11-18

INTRODUCTION

The Digi 4 Plus Systems Manual contains directions for installing, programming and operating your Digi 4 Plus. It is designed for both experienced and inexperienced users. Companion documents are the Digi 4 Plus Maintenance Manual and the Digi 4 Plus Quick Reference.

The manual has 11 sections and two appendixes:

- Section 1 contains a system overview.
- Section 2 contains installation instructions.
- Section 3 describes the operator panel and explains how to generate program listings.
- Section 4 describes channel assignments.
- Section 5 describes functions.
- Section 6 describes sources, system timers, constants and historical buffers.
- Section 7 describes channel limits, limit operational codes and relays.
- Section 8 describes messages and labels.
- Section 9 describes reports.
- Section 10 describes configuration codes.
- Section 11 describes the communications port.
- Appendix A describes the order of operation
- Appendix B contains the product warranty.

SECTION 1 - SYSTEM OVERVIEW

1.1 SYSTEM DESCRIPTION 1-1

1.2 OPERATION. 1-3
1.2.1 Inputs 1-3
1.2.2 Processing 1-4
1.2.3 Output 1-6

1.3 GETTING STARTED 1-9

1.1 SYSTEM DESCRIPTION

The Digi 4 Plus uses analog and digital inputs and outputs to perform industrial data acquisition and control. It provides accurate measurements, process/machine interfaces, a library of application-specific functions and algorithms. The Digi 4 Plus can stand alone for local control and monitoring or multiple Digi 4 Plus' can operate in a network. It can communicate with an intelligent terminal, computer or another Digi 4 Plus and can transmit data to a CRT or printer.

Add one of Kaye's real-time, multi-tasking software packages, KVIEW, KVIEW/ARTIC, KDIAL and KDAWS[1], and network multiple Digi 4 Plus' with an microcomputer that has standard AT architecture.

Digi 4 Plus uses a function-oriented programming language to process data. The functions range from simple voltage measurement to complex PID control algorithms. It has multiple timers and counters for interval, time-of-day, weekly or monthly actuation and Boolean operators for logic-based decisions.

A built-in library of firmware functions provides quick and accurate calculations. Digi 4 Plus firmware can convert linear and nonlinear input signals into engineering units and perform standard deviation, totalization, logarithmic, exponential, square root and trigonometric functions. Use its industry-specific application firmware to calculate the specific volume of steam and natural gas, steam enthalpy, volumetric flow rates, compressor efficiencies and lethality rates. Use its logic and control functions to implement PID, auto/manual and track-and-hold functions. Its sequencer function is ideal for machinery monitoring, ramp-and-soak heating control and other batch operations.

Digi 4 Plus is available in two hardware types: Digistrip 4 Plus and Digi-Link 4 Plus. The Digistrip 4 Plus, with a built-in line printer, is ideal for dedicated applications where local process documentation and trending are required. The Digi-Link 4 Plus, housed in a NEMA cabinet is well suited to heavy industrial environments and remote locations. Both have identical architecture and components and the same alarming, reporting and communications capabilities.

There are three Digi 4 Plus models that differ only in the functions supported: 4S (scanner), 4M (monitor) and 4C (controller). Table 1-1 on the following page summarizes their functionality. Section 5 describes the functions.

---

1. KVIEW, KVIEW/ARTIC, KDIAL and KDAWS are trademarks of Kaye Instruments, Inc.

Table 1-1. Model 4C, 4M and 4S Functions

4C	4M	4S
Voltage	Voltage	Voltage
Linear Input	Linear Input	Linear Input
Thermocouple	Thermocouple	Thermocouple
RTD	RTD	RTD
Multi-Segment Input	Multi-Segment Input	Multi-Segment Input
Linear Transfer	Linear Transfer	Linear Transfer
Multi-Segment Transfer	Multi-Segment Transfer	Multi-Segment Transfer
Accumulation	Accumulation	Accumulation
Meter	Meter	Meter
Counter	Counter	Counter
Interval	Interval	Interval
Elapsed Timer	Elapsed Timer	Elapsed Timer
Historical Buffer	Historical Buffer	Historical Buffer
Channel Group	Channel Group	Channel Group
Pair	Pair	Pair
Math	Math	Math
Polynomial Transfer	Polynomial Transfer	Polynomial Transfer
Data Storage	Data Storage	Data Storage
Boolean Logic	Boolean Logic	Boolean Logic
Flip-Flop	Flip-Flop	Flip-Flop
Data Compare	Data Compare	Data Compare
Controlled Transfer	Controlled Transfer	Controlled Transfer
Select	Select	Select
Integer Encoder	Integer Encoder	Integer Encoder
Control Counter	Control Counter	Control Counter
Control Timer	Control Timer	Control Timer
Logical Transfer	Logical Transfer	Logical Transfer
Relative Humidity	Relative Humidity	Relative Humidity
Cylindrical Tank Volume	Cylindrical Tank Volume	Cylindrical Tank Volume
Spherical Tank Volume	Spherical Tank Volume	Spherical Tank Volume
Lethality Rate	Lethality Rate	Lethality rate
Linear Weighting	Linear Weighting	
Specific Volume/Natural Gas	Specific Volume/Natural Gas	
Steam Enthalpy	Steam Enthalpy	
Specific Volume/Perfect Gas	Specific Volume/Perfect Gas	
Orifice Flow	Orifice Flow	
Orifice Meter	Orifice Meter	
Venturi Meter	Venturi Meter	
Flow Nozzle	Flow Nozzle	
Steam Saturation Pressure	Steam Saturation Pressure	
Steam Saturation Temperature	Steam Saturation Temperature	
Steam Entropy	Steam Entropy	
Water Specific Volume	Water Specific Volume	
Water Enthalpy	Water Enthalpy	
Water Entropy	Water Entropy	
Turbine Efficiency	Turbine Efficiency	
Turbine Exhaust State	Turbine Exhaust State	
Compressor Efficiency	Compressor Efficiency	
PID Control		
Sequencer		

1.2 OPERATION

Digi 4 Plus accepts analog and digital inputs, processes the data according to a fixed set of computational routines called functions and provides analog and digital outputs. It also accepts inputs from the keyboard and provides outputs to a printer or CRT. You can also connect a Digi 4 Plus to an intelligent terminal, computer or another Digi 4 Plus in a network configuration. Figure 1-1 is a simplified representation of system operation. Figure 1-4 at the end of this section is a more detailed block diagram.

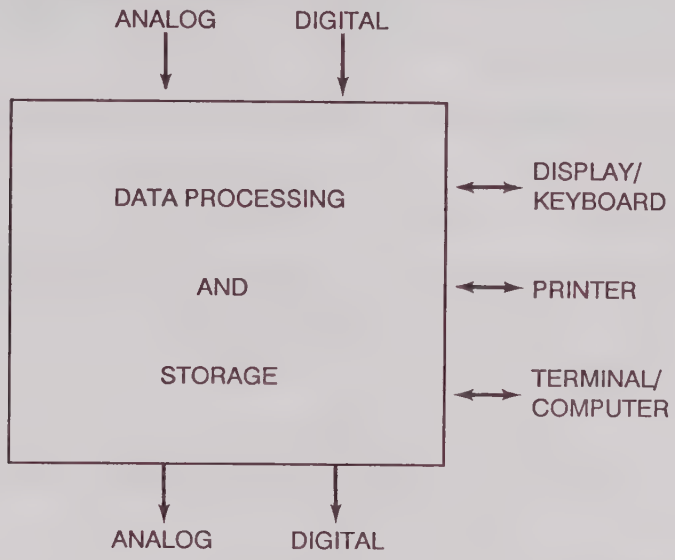


Figure 1-1. System Operation

1.2.1 Inputs

The Digi 4 Plus accepts up to 128 inputs. Data can come from an Analog Plus, RTD Plus, or status input scanner and/or an external scanner. You can mount up to 8 scanners on a Digistrip 4 Plus; you can mount up to 10 scanners on a Digi-Link 4 Plus. Each scanner accepts 16 inputs.

Analog Plus Scanners

Analog Plus scanners accept inputs from thermocouples, direct input voltages (0-12 VDC) and, if you use a shunt resistor, current inputs. They can also accept measurements from strain gauges, thermistors and/or transducers if the signals are conditioned at the input module.

Each Analog Plus scanner has a uniform temperature reference (UTR) block that provides cold junction compensation for thermocouples and minimizes temperature difference between inputs.

RTD Plus Scanners

RTD Plus scanners accept inputs from three-wire 100 ohm platinum and 10 ohm copper RTD's and provide the required excitation voltage and completion resistors.

Data from Analog Plus and RTD Plus scanners is sent to a row of channel addresses. The analog scan time is 40 channels per second at 60 Hz and 33 1/3 channels per second at 50 Hz (with one channel of overhead per scan and one channel of overhead per bank).

Status Input Scanners

Status input scanners accept digital inputs from external devices (switches, valves, acutators or operator pushbuttons). They can monitor voltages (24-48 VAC or 24-48 VDC) or, with a 24 volt power supply, they can monitor the open or closed condition of a dry contact. (The 24 volt power supply is build into the Digi-Link 4 Plus.) All status inputs are optically isolated.

Data from the status input scanners does not occupy channel space; it resides in another part of Digi's memory.

External Scanners

Digi 4 Plus also accepts input from an external scanner such as another Digi 4 Plus, a Kaye Frequency Scanner (FS-8) or a Kaye Digital Scanner (DS-8). Digi 4 Plus receives pulse, contact and frequency input from the FS-8 and binary or BCD input from the DS-8. The data from an external scanner enters the system via Peripheral Port 1 (PP1) or Peripheral Port 2 (PP2).

Data from external scanners is also sent to a row of channel addresses. Do not send data from an external scanner to a row of channel addresses that receives data from an Analog Plus or and RTD Plus scanner.

1.2.2 Processing

Digi 4 Plus processes all data at channels. A channel stores a function code and other information relevant to the function's operation. Each Digi 4 Plus has 128 channels (101-816) that form a matrix of 8 rows by 16 columns. Each channel has a unique 3-digit address that contains its row number and column number (101-116, 201-216, ...801-816.) Each channel address can store a fixed number of parameters. The function code determines which parameters require definition. The parameters can specify the decimal location, engineering units, sources of input data, limits set on the data and the action taken when data exceeds the limits. Figure 1-2 on the following page shows the channel matrix and structure of a channel.

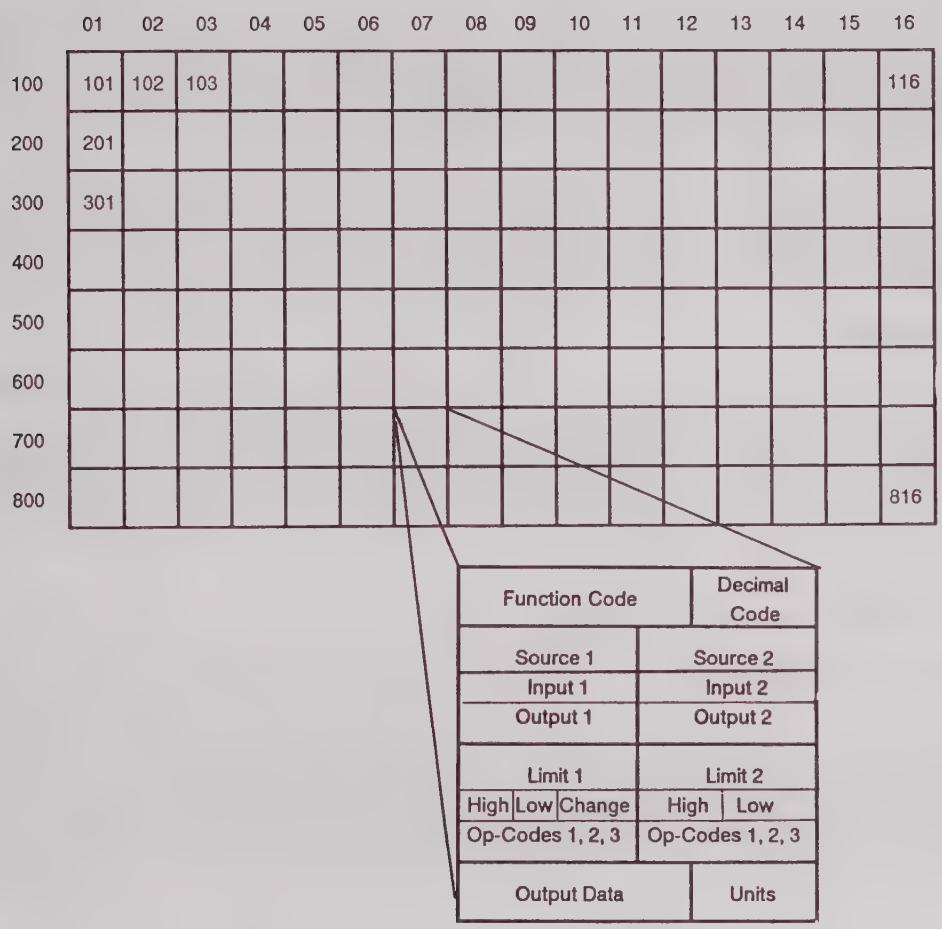


Figure 1-2. Channel Matrix and Channel Parameters

Digi 4 Plus also has 99 CALC channels (01-99). As their name implies, they are used solely for calculations. They do not process live input, output logical data or print one line messages. They do not have limit and limit op-code parameters and cannot be included in reports. Figure 1-3 shows CALC channel parameters.

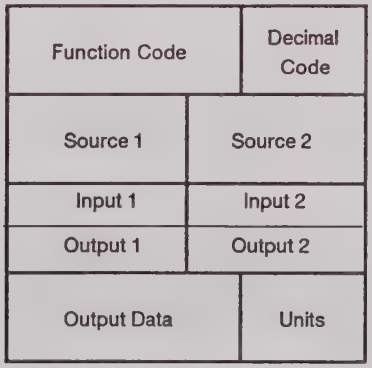


Figure 1-3. CALC Channel Parameters

Digi 4 Plus begins processing data at CALC Channel Address 01 and continues sequentially through the CALC channel and channel addresses. It skips channels that are not assigned a function code. The time required to process a set of input data and to establish a new set of outputs is called the math scan. The math scan can vary from 0.30 to 2.00 seconds, depending upon the complexity of the program.

Most functions require a single channel address and input data to complete their computational routines. A three-digit number, called the source, specifies the address of the channel input data. There are three types of channel input data: analog, numerical and logical.

Analog Input

Analog input comes from a thermocouple, RTD, voltage or current source. For example, suppose we connect 16 Type T thermocouples to a Digi 4 Plus and send data to the channels in Row 400. If we assign the corresponding thermocouple function to Channel Addresses 401-416, Digi 4 Plus converts the voltage to a temperature reading and stores the result at the channels. Another function that operates on numerical input data can use this temperature reading as input data.

Numerical Input

Numerical input comes from channel and CALC channel addresses and global system parameters. (Global system parameters store information about the system's internal operation, such as the date/time or the length of the last power outage.) For example, suppose we assign a multiplication function to Channel 503. (A multiplication function operates on numerical input data from two sources.) If we specify Source 1 as 716 and Source 2 as 802, Digi 4 Plus multiplies the numerical data at Channel Address 716 by the numerical data at Channel Address 802. It stores the product at Channel Address 503. Another function that operates on numerical input data can use the product as input data.

Logical Input

Logical input (the true or false state of a logic bit) can come from relay addresses, status input addresses, channel addresses and system timer addresses. For example, assume the thermocouple function at Channel 402 measures the temperature of water in a tank. Suppose we define a limit of 32.0 and specify the logic bit at Channel Address 402 turns true when the limit is exceeded. Another function that operates on logical input data can use the logic bit as input data.

1.2.3 Output

Digi 4 Plus can output analog and digital data to peripherals, communicate with a computer and transmit data to a CRT, printer or another Digi 4 Plus.

Analog Output

Digi 4 Plus can output data to optional Dual Analog Output modules. Each Dual Analog Output module provides two current transmitter output s that convert 0 to 10,000 counts to an isolated, floating 4-20 mA signal. These signals can be used for control, trend recording, X-Y plotting or indication.

Digital Output

Digi 4 Plus can output the states of its 48 internal relay logic bits to optional Relay Closure modules, solid state or electromechanical. Solid state relays are available in the Quad Relay module, which is controlled by the D4 Output Driver, or the Solid State Relay Closure. Electromechanical relays are available in the electromechanical relay output unit.

Digi 4 Plus also has 2 master relays and a watchdog relay. Its internal relay logic bits control the master relays, which can turn on external devices such as annunciators. The watchdog relay remains closed when the Digi 4 Plus is operating normally. If a system error or a power outage occurs, the watchdog relay opens.

Printer Port

Digi 4 Plus can send reports and messages to a printer or CRT via the RS-232 or current loop printer port. (The RS-232 printer port on a Digistrip 4 Plus is dedicated to its internal printer.)

Communications Port

Digi 4 Plus can send serial data to a computer or terminal via the communications port (current loop or RS-232).

Operator Panel Displays

The Digi 4 Plus operator panel contains LED's that display the current date and time, the latest channel data, the time interval and reset time for each system timer and the values assigned to parameters. Seven system indicator lights alert you to system conditions.

Cassette Program Loader

Digi 4 Plus can offload and load entire programs to a Kaye Model CPL-2 Cassette Program Loader. While a program is offloaded, all transmission via Peripheral Port 2 stops. While a program is loaded, all system operation stops.

Another Digi 4 Plus

Digi 4 Plus can transmit data to another Digi 4 Plus via Peripheral Port 1 (PP1) or Peripheral Port 2 (PP2).

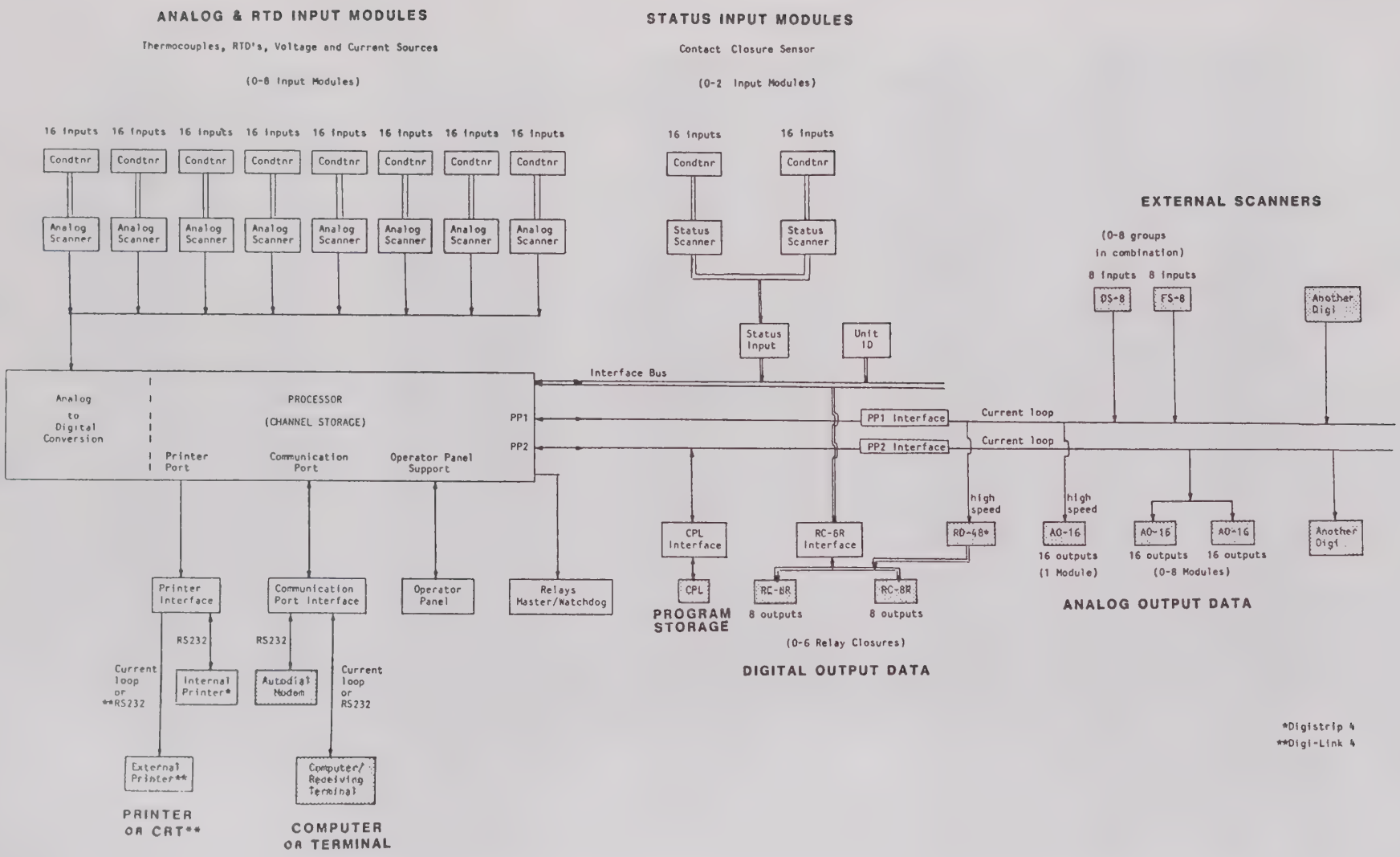


Figure 1-4. System Block Diagram

1.3 GETTING STARTED

Now that we've described the Digi 4 Plus and explained how it operates, it's time for you to get started. Refer to the sections referenced for detailed instructions. We recommend the following order:

1. Install your Digi 4 Plus system (Section 2). First, load the paper (Digistrip 4 Plus). Initialize the system and set the system clock. Caution: initialization erases any existing program and restores the system defaults. Then connect your peripherals to the Interface I/O panel and your inputs to the scanners. Notice that the scanners are color coded: black is for analog inputs, blue is for RTD inputs and red is for status inputs. Finally, Use Configuration Codes 001 and 002 to map input data from your scanners to rows of channel addresses (Section 10).

2. Familiarize yourself with the operator panel (Section 3). You use the keyboard or a computer to make all entries. The LED displays and indicator lights provide data and system status information. A beeper signals valid and invalid entries and alarm conditions.

Two passwords provide system security. One restricts access to the Program mode; the other restricts access to the communications port computer protocol (CXT). You can also secure other parameters.

Digi 4 Plus must be in the Program mode to enter a function code, decimal code, configuration code and set the system clock.

3. Assign a function code (Section 5) to each channel that is to accept an input or perform a calculation. The function code specifies the exact operation Digi 4 Plus performs on channel data and must be assigned first. For example, you might want to find the maximum, minimum or average of a group of temperatures or calculate the standard deviation.

Depending on the function code, you may also assign parameters that specify what is done with the calculated data (Section 4). The decimal code defines the resolution of the data; units specifies a single character engineering unit.

Sources (Section 6) identify the location of channel input data. Limits (Section 7) set a bounds against which channel output data is compared. The limit could be high, low or rate of change. Limit op-codes (Section 7) specify the action taken when a limit is reached. For example, a limit op-code could activate a relay, turn on an alarm or issue a message.

4. Define configuration codes (Section 10). Configuration codes are system instructions. They specify basic configuration, system reporting, output to peripheral devices, relay latching and passwords. For example, one set of configuration codes controls the content and format of reports. Another set controls message output.

5. Enter text and/or data for reports, messages and labels. Reports (Section 9) are a record of system output data. Digi 4 Plus can generate four independent data reports and one alarm status report. Each data report can contain data from channels, historical buffers and the logic states of the relays and status inputs. The alarm status report lists channels currently in alarm.

With auto-trend, you can configure one data report to generate up to 9 different trends. Auto-trend can graph analog inputs such as temperatures, pressures and flows, calculated values and is available with the Digistrip 4 Plus.

Reports can be automatically generated at regular intervals by logic sources, or manually initiated by pressing the LOG key. Digi 4 Plus can print reports locally or transmit them to a computer or terminal. Or it can store reports in the text output buffer for printing and/or transmission at a later time.

Messages and labels (Section 8) are textual descriptions of displayed data. Digi 4 has 99 text addresses that store user--defined messages. For example, a message can signal limit action and sequencer operation or specify telephone numbers for auto/dial.

6. Configure your Kaye software. See the documentation supplied with your software package for directions.

SECTION 2 - INSTALLATION

2.1 GENERAL INFORMATION 2-1

2.2 INSTALLING A DIGISTRIP 4 PLUS 2-1
- 2.2.1 Connecting Peripherals 2-4
- 2.2.2 Connecting Analog Inputs 2-10
- 2.2.3 Connecting Status Inputs 2-15
- 2.2.4 Initializing the System 2-16
- 2.2.5 Setting the System Clock 2-17
- 2.2.6 Loading Paper 2-18
- 2.2.7 Test Mode 2-19

2.3 INSTALLING A DIGI-LINK 4 PLUS 2-20
- 2.3.1 Connecting Peripherals 2-22
- 2.3.2 Connecting Analog Inputs 2-22
- 2.3.3 Connecting Status Inputs 2-22
- 2.3.4 Initializing the System 2-23
- 2.3.5 Setting the system clock 2-23

LIST OF FIGURES

Figure 2-1. Digistrip 4 Plus (Front View) 2-2
Figure 2-2. Digistrip 4 Plus (Rear View) 2-2
Figure 2-3. Digistrip 4 Plus (Rear View with Expander Box) 2-3
Figure 2-4. Digistrip 4 Plus (Right Side of Chassis) 2-3
Figure 2-5. Digistrip 4 Plus (Left Side of Chassis) 2-4
Figure 2-6. Interface I/O Panel 2-4
Figure 2-7. RD-48/AO-16 Series Connections (PID Control Applications) 2-8
Figure 2-8. DS-8 and/or FS-8 Connections (Port 1 Only) 2-8
Figure 2-9. DS-8 and/or FS-8 Connections (Port 1 and Port 2) 2-9
Figure 2-10. AO-16 Connections (Non-PID Control Applications) 2-10
Figure 2-11. Analog Plus Scanner Terminals 2-11
Figure 2-12. Voltage Transducer Connections 2-11
Figure 2-13. VD-100/Voltage Transducer Connections 2-11
Figure 2-14. Current Transmitter Connections 2-12
Figure 2-15. Thermocouple/Analog Plus Scanner Connections 2-13
Figure 2-16. Thermocouple/Automatic Ice Point Reference Connections 2-14
Figure 2-17. Thermocouple/Uniform Temperature Reference Connections 2-14
Figure 2-18. RTD Plus Scanner Connections 2-15
Figure 2-19. Status Input Connections 2-16
Figure 2-20. Digistrip 4 Plus Printer 2-19
Figure 2-21. Sample Test Mode Printout 2-19
Figure 2-22. Digi-Link 4 Plus in Standard NEMA Enclosure 2-21
Figure 2-23. Digi-Link 4 Plus Display and Interface Panels 2-22
Figure 2-24. Digi-Link 4 Plus Fully Populated 2-22

LIST OF TABLES

Table 2-1. Digistrip 4 Plus Scanner Combinations 2-1
Table 2-2. Digi 4 Plus Peripheral Connections 2-5
Table 2-4. Shunt Resistor Guide 2-12
Table 2-5. Scanners in Standard NEMA 4 2-20

2.1 GENERAL INFORMATION

Digi 4 Plus is available in two hardware versions: Digistrip 4 Plus and Digi-Link 4 Plus. Both versions have the same communications capabilities. By repackaging the hardware, Kaye created two mainframe versions for use in different applications.

Digistrip 4 Plus has a totally enclosed line printer that provides full-page reporting. The printer uses an upper case ASCII character set and can print up to one line per second, With Kaye's Auto-Trend package, Digistrip 4 Plus can also produce full-page trend reports with trace indicators and associated digital data.

The Digi-Link 4 Plus is packaged in a NEMA 4 enclosure. All components and accessories, including the operator keyboard and display, are mounted inside the cabinet. It's a compact, dependable match for rugged industrial environments or remote locations. Digi-Link 4 Plus does not have a built-in printer, but you can easily connect it to one via the printer port (current loop or RS-232).

Because of the hardware differences, installation procedures are described separately. Section 2.2 contains directions for Digistrip 4 Plus. Section 2.3 contains directions for Digi-Link 4 Plus. The Digi 4 Plus Maintenance Manual contains system wiring diagrams and schematics for both systems.

2.2 INSTALLING A DIGISTRIP 4 PLUS

A Digistrip 4 Plus system contains a Digi, peripherals and accessories. The Digistrip 4 Plus is completely assembled. Peripherals and accessories may be packaged separately.

For most applications, panel mount the system or install it in an instrument rack or cabinet. As an alternative, you can place it on a bench top. For maximum operating reliability and accuracy, maintain the ambient temperature of the installation in the 0-50C (32-125F) range and do not let the relative humidity exceed 95% (non-condensing).

Each Digi 4 Plus has an Interface I/O panel (Figures 2-2 and 2-3) and spaces on the back for four scanners (Analog Plus, RTD Plus and status input). An optional expander box can hold four additional scanners.

Table 2-1 lists scanner combinations for systems with and without an expander box. Figures 2-2 and 2-3 show typical mounting configurations. Mount Analog Plus and RTD Plus scanners in any available spaces. Mount status input scanners only in the spaces shown in Figures 2-2 and 2-3. If you must mount status input scanners in other spaces, a special cable is required.

Table 2-1. Digistrip 4 Plus Scanner Combinations

Without Expander Box			
Number of Analog Plus and/or RTD Plus scanners	0-2	3	4
Maximum number of status input scanners	2	1	0
With Expander Box			
Number of Analog Plus and/or RTD Plus scanners	0-6	7	8
Maximum number of status input scanners	2	1	0

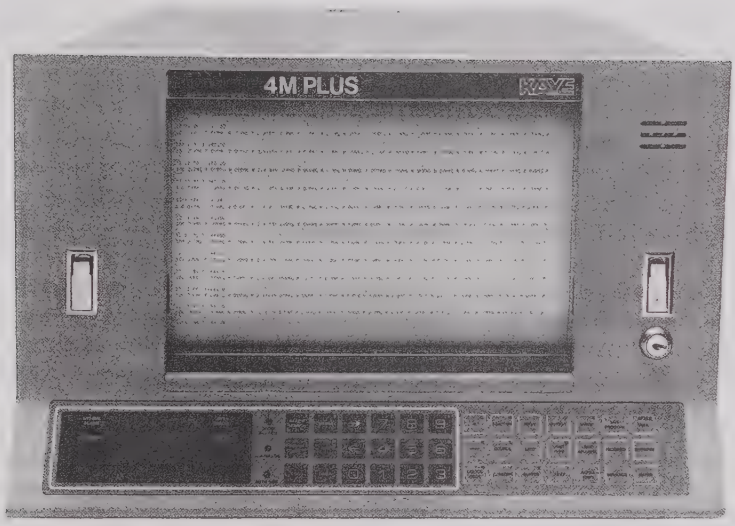


Figure 2-1. Digistrip 4 Plus - Front View

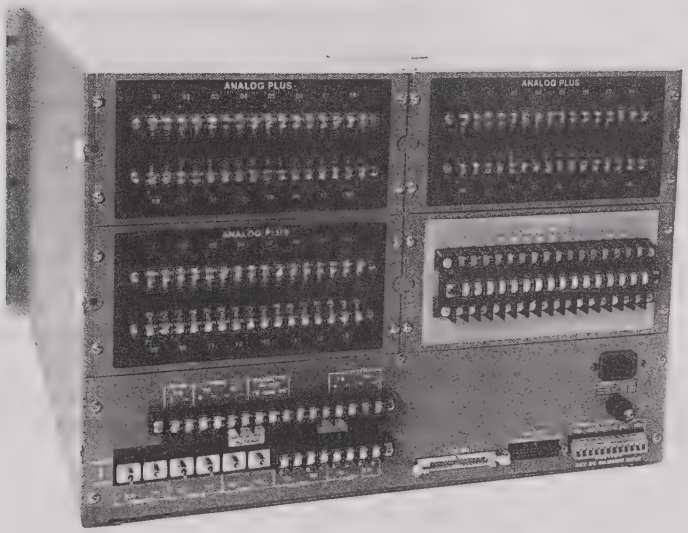


Figure 2-2. Digistrip 4 Plus - Rear View

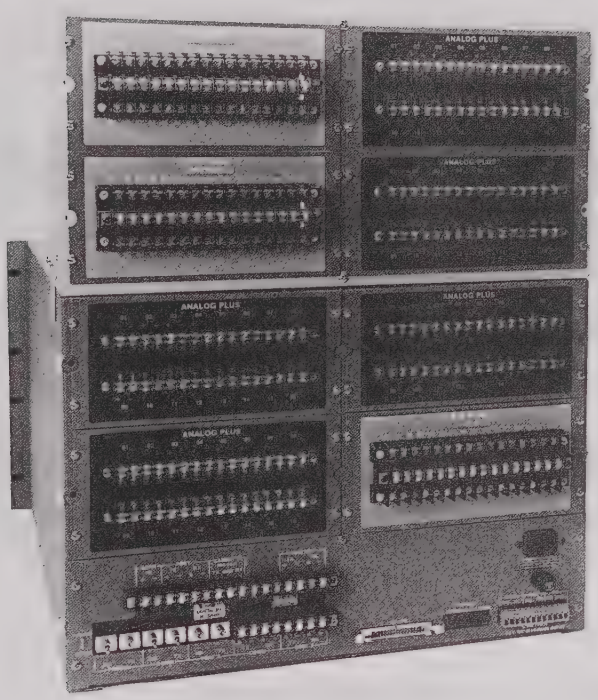


Figure 2-3. Digistrip 4 Plus - Rear View with Expander Box

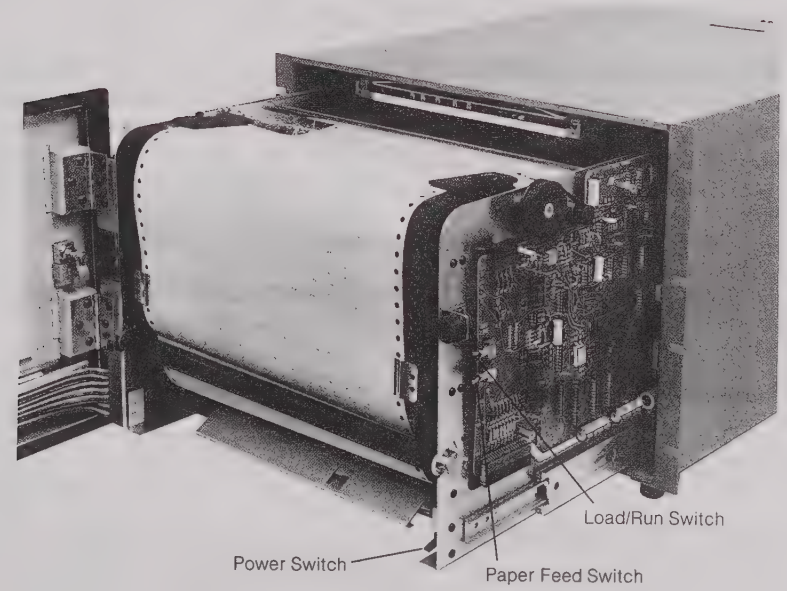


Figure 2-4. Digistrip 4 Plus - Right Side of Chassis

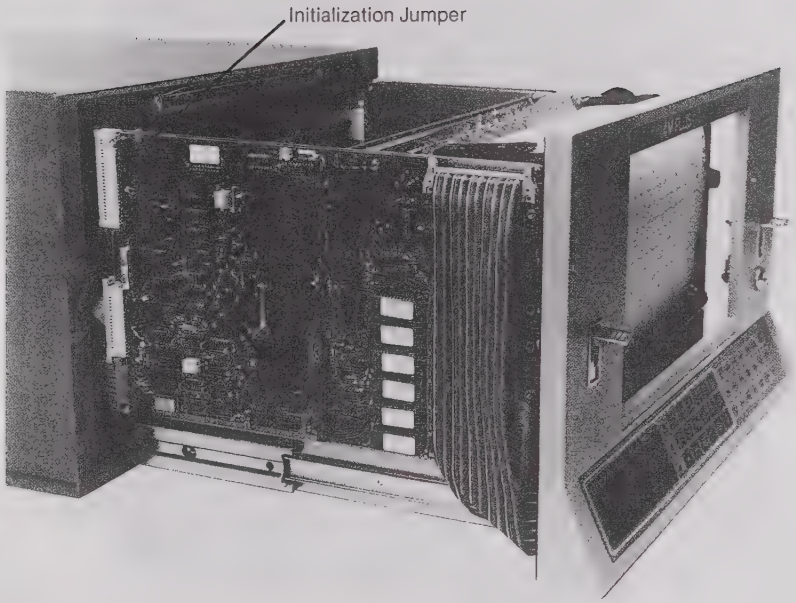


Figure 2-5. Digistrip 4 Plus - Left Side of Chassis

2.2.1. Connecting Peripherals

Connect peripherals via the connection ports on the Interface I/O panel (Figure 2-6). Table 2-2 on the following page lists peripheral connections.

Before wiring your system, determine what you expect for input and output data; then create and enter a program for it. When connecting + and - terminals, always connect + to + and - to -. When connecting TX (transmit data) and RX (receive data) terminals, always connect TX terminals of one device to the RX terminals of the other. When connecting peripherals and setting switches, make sure Digistrip 4 Plus' power is off.

WARNING

Dangerous, user-supplied voltages can be present at the relay output connector on the Interface I/O panel, even if the power is off.

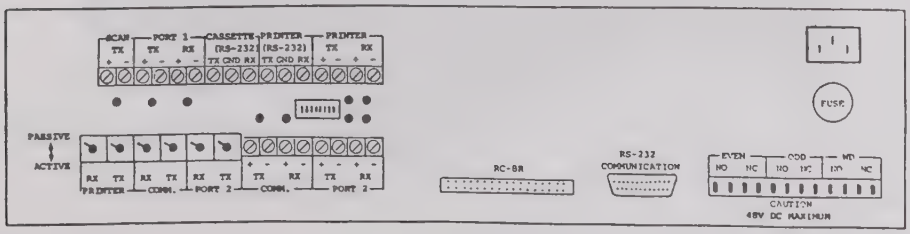


Figure 2-6. Interface I/O Panel

Digi 4 Plus also supports D4 Output modules that are mounted with Digi 4 Plus and linked by a driver module. Each analog module has two channels (4-20mA or 0-16 mA); each relay module has four channels. Relay closures are solid state AC or DC. You can mix or match up to 12 modules. See the documentation supplied with your D4 Output modules for more information.

Table 2-2. Digi 4 Plus Peripheral Connections

Peripheral	Peripheral Terminals	Digi 4 Plus Terminals
DS-8 and FS-8 scanners (Up to 8 in series)	TX+, TX- (act.) RX+, RX- (act.)	RX+, RX- Port 1[1] TX+, TX- Scan
Analog output modules (Up to 8 in series - not used for PID)	RX+, RX- (act. or pass.)	TX+, TX- Port 2[2]
Analog output module (Continuous high speed data trans. - 1 module)	RX+, RX- (act.)	TX+, TX- Port 1
Relay closures (Up to 6 wired in series)	Ribbon cable connector	RC-8R connector
RD-48 relay driver (Remote operation of relay closures)	RX+, RX- (act.)	TX+, TX- Port 1
Computer, terminal, CRT (current loop)	TX+, TX- RX+, RX- (act. or Pass.)	RX+, RX- TX+, TX- Com Port[2]
Computer, terminal CRT, modem (RS-232)	RS-232 Connector (DCE - full duplex)	Com (RS-232) (DTE - full duplex)
Line printer (current loop)	TX+, TX- RX+, RX- (act. or pass.)	RX+, RX- TX+, TX- printer[2]
Line printer (RS-232 - discrete connections TX, RX, GND)	TX RX GND	RX TX printer (RS-232) GND
CPL-2 cassette program loader (RS-232)	TX RX GND	RX TX cassette GND
Another Digi 4 Plus (receive date from other Digi)	TX+,TX- Port 2 (pass.)	RX+, RX- Port 2 (act.)[2]
Another Digi 4 Plus (transmit date to other Digi)	RX+,RX- Port 2 (pass.)	TX+, TX- Port 2 (act.)[2]

1. You can connect up to 8 additional DS-8 and FS-8 scanners in series to the RX+ and RX- terminals of Port 2 if you also wire the synchronization pulse output of the Scan port in series to the scanners.

2. Use the active/passive switches on the Interface I/O panel to specify active or passive operation of the Current Loop ports (Printer, Communication and Port 2). If the peripheral is passive, the Digi 4 Plus port must be active.

RC-8R Port

The RC-8R port connects relay closure modules directly to Digi 4 Plus. Use the multi-connector ribbon cable supplied with the relay closure to connect up to six relay closure modules in series (up to 48 relays). Set the DIP switch on each relay closure module to a unique relay group. For remote relay closures, connect an RD-48 relay driver to the transmit terminals of Port 1. See the documentation supplied with your relay closure modules for more information.

Communications Port (RS-232)

The RS-232 communications port connects a computer, terminal, CRT or modem to a Digistrip 4 Plus. This port contains all the circuitry required for RS-232 data communication. See Section 11 for more information.

The RS-232 communications port is a twenty-five pin connector wired in Data Terminal Equipment (DTE) configuration. Table 2-3 shows the pin configuration. See Section 11 for more information.

Table 2-3. RS-232 Communications Port Pin Configuration

Pin Number	Signal Description
1	Protective Ground
2	Transmitted Data
3	Received Data
4	Request to Send
5	Clear to Send
6	Data Set Ready
7	Signal Ground
8	Received Line Signal Detector
21	Signal Quality Detector
22	Ring Indicator

Use only pins 2,3 and 7 for RS-232 communication with most peripheral devices. When connecting a Digi 4 Plus to a peripheral device wired in the Data Communication Equipment (DCE) configuration, use a cable that connects pin 2 to pin 2, pin 3 to pin 3 and pin 7 to pin 7. When connecting a Digi 4 Plus to a peripheral device wired in Data Terminal Equipment (DTE) configuration, use a cable that connects pin 2 to pin 3, pin 3 to pin 2 and pin 7 to pin 7.

Use standard RS-232 modems for remotely-initiated modem communication over telephone lines. If you enable auto-dial, you must install a Hayes Smartmodem Model 1200 or 2400 at the Digi 4 Plus. See Section 11 for more information.

Communications Port (Current Loop)

The current loop communications port connects a computer, terminal or printer to Digi 4 Plus. Specify the communications port baud rate via Slides 1-3 of DIP Switch S7 on the Interface I/O panel (Figure 2-6). The baud rate must match the peripheral with which it is communicating.

Set the COMM toggle switches (Figure 2-6), to specify the communications port for either active or passive operation. When the peripheral is active, the communications port must be passive. When the peripheral is passive, the communications port must be active. See Section 11 for more information.

Relay Output Port

The relay output port (EVEN/ODD/WD) has output terminals for the odd and even master relays and the watchdog relay. You can use the output of these relays to control the operation of external devices such as indicator lights and automatic shut-offs. The load on any device connected to these relays should be resistive and should not exceed 220 VAC (2A). The relay output port has both normally open (NO) and normally closed (NC) outputs for each relay. For a normally open output, connect the device to the NO terminals. For a normally closed output, connect the device to the NC terminals.

Assign limits and limit op-codes to specify odd and even master relay operation. Digits 1-3 of Configuration Code 007 specify master relay operation mode. When a limit tied to the odd or even master relay is exceeded, the relay trips and can turn off a device connected to the output terminals of that relay. For example, if you connect an indicator light to the normally closed (NC) output terminals of the odd master relay, the light remains on as long as the odd relay output is closed and goes off when the odd relay output opens.

The watchdog relay is tied to a continuous system diagnostic routine. During normal operation, it is closed. If a power outage or system malfunction occurs, the watchdog relay opens. By connecting an external device such as an indicator light or automatic shut-off to the watchdog relay, you can use it to turn the device on or off. See Section 7 for more information.

Scan Port

The scan TX+ and TX- terminals transmit synchronization pulses once a minute to a DS-8 digital scanner, an FS-8 frequency scanner or a combination of digital and/or frequency scanners wired in series. See the documentation supplied with your scanners for more information.

Port 1

The Port 1 terminals provide TTY current loop data communication with Kaye peripherals. Port 1 is a passive current loop transmitter and receiver.

The Port 1 TX+ and TX- terminals continuously transmit a single line of channel data and relay information at 4800 baud to an analog output module and/or an RD-48 relay driver.

In PID control applications, where a single line of channel data and relay information is continuously transmitted at 4800 baud to an AO-16 and relays, connect the AO-16 to the Port 1 TX+ and TX- terminals and the relay closure modules directly to the RC-8R port. In applications that require remote relay closures, wire an RD-48 relay driver and AO-16 in series to the Port 1 TX+ and TX- terminals (Figure 2-7). Set the baud rate of the AO-16 and the RD-48 for 4800 and the ACTIVE/PASSIVE jumper on the AO-16 for passive operation. See the documentation supplied with these devices for more information.

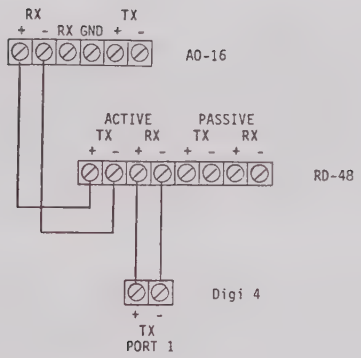


Figure 2-7. RD-48/AO-16 Series Connections (PID Control Applications)

The Port 1 RX+ and RX- terminals receive data at 1200 baud from up to eight DS-8 digital scanners and/or FS-8 frequency scanners wired in series (Figure 2-8). When connecting scanners to Port 1, a synchronization pulse provided by the scan port must be transmitted to the scanners at one-minute intervals. In addition, assign a 3 to Digit 3 of Configuration Code 002 (begin new analog scan every 10 seconds); set the baud rate jumper on each scanner to 1200 and the DIP switch on each scanner to a unique channel group. See the documentation supplied with your scanners for more information.

You can also connect up to eight additional scanners to the Port 2 RX+ and RX- terminals (Figure 2-9).

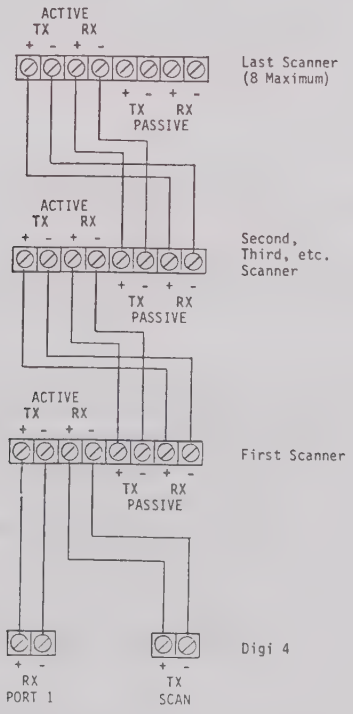


Figure 2-8. DS-8 and/or FS-8 Connections (Port 1 Only)

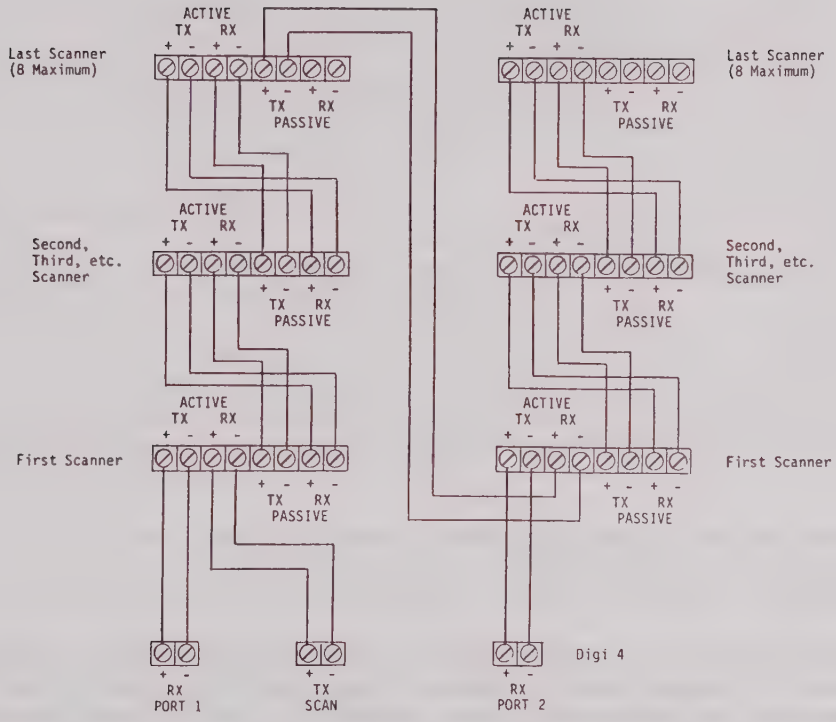


Figure 2-9. DS-8 and/or FS-8 Connections (Port 1 and Port 2)

Port 2

The Port 2 terminals provide TTY current loop data communication with Kaye peripherals. Set the port toggle switches to specify Port 2 for either active or passive operation.

Digit 2 of Configuration Code 003 specifies the baud rate. 0 = 2400 baud (default); 1 = 1200 baud.

The Port 2 TX+ and TX- terminals transmit data in RAMP format. This data can be transmitted to another Digi 4 Plus or to one or more AO-16's wired in series (for applications other than PID control). You can wire up to eight AO-16's in series to a Digi 4 Plus (Figure 2-10). Set the baud rate jumper on each AO-16 to match the Port 2 baud rate and set the DIP switch on each AO-16 to a unique channel group. See the documentation supplied with your AO-16 for more information.

The Port 2 RX+ and RX- terminals receive data in RAMP format from Port 2 of another Digi 4 Plus. Specify the same Port 2 baud rate (1200 or 2400) for both units and assign a 1 to Digit 3 of Configuration Code 002 of the receiving unit (begin new analog scan every 10 seconds).

When transmitting data in RAMP format, Digi 4 Plus disregards the decimal point location and formats the data as if it were a 60mV range reading. Therefore, treat data received by one Digi 4 Plus from another as voltage readings (60 mV range). Assign the channel that receives the data a 60 mV linear input function and scale its output.

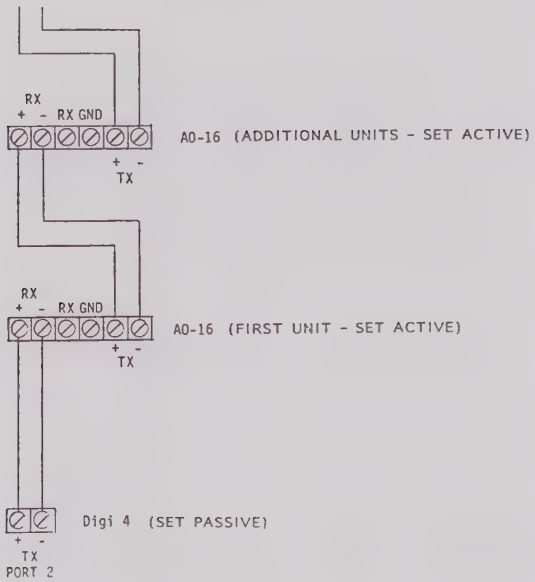


Figure 2-10. AO-16 Connections (Non-PID Control Applications)

Cassette Port

The cassette port communicates with a CPL-2 cassette program loader in RS-232 format at 1200 or 2400 (default) baud. Because the cassette port and Port 2 share certain hardware, both ports must have the same baud rate. Digit 2 of Configuration Code 003 specifies the baud rate.

Printer Port (RS-232)

The RS-232 printer port transmits reports and messages to a printer in RS-232 format. Its data stream is the same as that transmitted to Digistrip 4 Plus' internal printer. Digit 3 of Configuration Code 004 specifies the baud rate. The baud rate must match that of the printer used. Set an external printer for even parity. XON/XOFF protocol is supported.

Printer Port (Current Loop)

The current loop printer port transmits reports and messages to an external printer in TTY current loop format. Its data stream is the same as that sent out the RS-232 printer port. Digit 3 of Configuration Code 004, which must match that of the printer used. Set the external printer for even parity. XON/XOFF protocol is supported.

Set the toggle switches to specify the printer port for either active or passive operation. When the printer is active, the printer port must be passive. When the printer is passive, the printer port must be active.

2.2.2 Connecting Analog Inputs

Digi 4 Plus can monitor up to 128 channels of analog input data. You can mount up to four 16-channel Analog Plus scanners on the back of a Digistrip 4 Plus. Systems with an expander box can hold up to eight scanners. Figure 2-2 shows a Digistrip 4 Plus with one scanner. Figure 2-11 on the following page shows the Analog Plus scanner terminals.

Figure 2-11. Analog Plus Scanner Terminals

Each scanner can receive analog input signals from up to 16 external devices (voltage transducers, current transmitters, thermocouples or resistive devices).

Digi 4 Plus can accept analog inputs as DC voltages or DC currents. It converts all inputs to voltages before measurement. Input voltage cannot exceed +/-12000mV (+/-12V). Wire a voltage input directly to the two terminals of an input terminal pair. A current input requires a precision shunt resistor across the input terminals to convert the current into a measurable voltage.

Connect thermocouples directly to the input terminals of an Analog Plus scanner and the Digi 4 Plus automatically provides an internal ice-point reference. You can also connect thermocouples to an external ice point reference or a uniform temperature reference.

When connecting input leads to the terminals of an Analog Plus scanner, the scanner multiplexes input data from each terminal pair and directs it to a particular channel row. Configuration Codes 001 and 002 determine the channel row to which each scanner's data is directed.

Voltage Transducers

Connect voltage transducers to the terminals of a 4 Plus analog scanner (Figure 2-12). Digi 4 Plus can accept a maximum voltage of +/-12000mV (+/-12VDC). A VD-100 voltage divider (Figure 2-13) is required for inputs greater than +/-12000mV. The VD-100 is a 100-to-1 voltage divider you can mount on an input terminal pair.

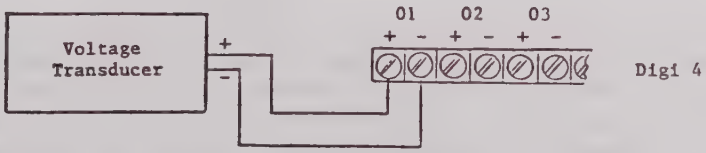


Figure 2-12. Voltage Transducer Connections

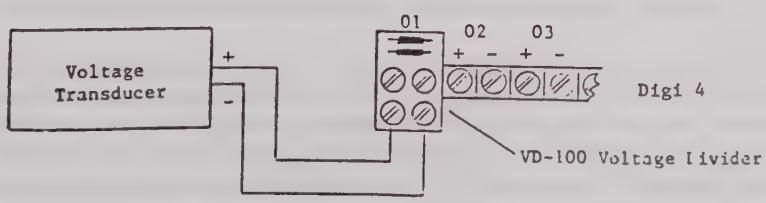


Figure 2-13. VD-100/Voltage Transducer Connections

Current Transmitters

Connect current transmitters to the input terminals of the Analog Plus scanner (Figure 2-14). You must also install a precision shunt resistor across Digi-strip 4 Plus' input terminals to convert the current into a measurable voltage. The equation that determines the voltage of a circuit containing a shunt resistor is E = IR where:

E = Voltage
I = Current (Amperes)
R = Resistance (Ohms)

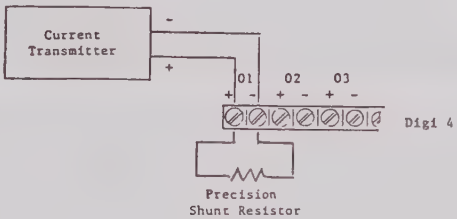


Figure 2-14. Current Transmitter Connections

Table 2-4. Shunt Resistor Guide

Input Range	Precision Shunt Resistor	Voltage Measuring Range
1-5 ma	250 Ohm	250-1250 mV
4-20 ma	250 Ohm	1000-5000 mV
4-20 ma	62.5 Ohm[3]	250-1250 mV
10-50 ma	62.5 Ohm[3]	625-3125 mV

Thermocouples

Functions 018-038 (thermocouple) provide linearization for a variety of thermocouple types. Depending on the function, the output can be either C or F. Depending on the Source 1 and Source 2 values, you can specify internal or external referencing and/or filtering. See Section 5 for more information.

Each thermocouple has a measuring junction and a terminal junction. The measuring junction is the point at which the temperature is measured; the terminal junction is the point at which the thermocouple leads are converted to copper. The millivolt output depends on the temperature difference between the measuring junction and the terminal junction. When connecting a thermocouple directly to the copper analog input terminals on Digi 4 Plus, the terminals become the terminal junction. When connecting it to the terminals of an external referencing device (such as an automatic ice point reference or uniform temperature reference), the external device provides the terminal junction.

The standard conversion of voltage to temperature assumes the terminal junction is at the ice point (0+/-C). To compute the correct temperature, reference the output of the thermocouple to the ice point (0°C) before making the computation. Ice point referencing is the algebraic addition of millivolt output of the thermocouple to millivolt output that would be generated by the thermocouple type between the ice point temperature (0°C) and the terminal junction temperature.

---

3. Kaye Instruments Part # N0870

The ice point reference voltage can be generated by a reference thermocouple of the same type with its measuring junction at the ice point and its terminal junction at the temperature of the measuring thermocouple's terminal junction. This generates the negative of the reference voltage. Alternatively, the ice point reference can be an electronically generated millivolt value equal to the millivolt value generated by a reference thermocouple. Algebraic addition of the millivolt value of the ice point reference voltage to the millivolt value of the thermocouple voltage provides a millivolt value equal to that produced if the thermocouple had its terminal junction at the ice point ($0^{O}C$). After determining this referenced millivolt value, the function scales the data to produce the temperature output.

Digi 4 Plus assumes that an external ice-point reference voltage is generated by a thermocouple (of the same type) with its measuring junction at the ice-point and its terminal junction connected to the same isothermal terminal block as the measuring thermocouples. Because this is the negative of the appropriate ice-point reference voltage, Digi 4 Plus subtracts, rather than adds, the reference voltage.

The following pages describe installation of thermocouples. Always connect the + lead to the + input terminal and the - lead to the - input terminal. Per the ANSI standard, the negative thermocouple lead is normally red.

Thermocouples/Analog Plus Scanner Connections

Thermocouples connected directly to Analog Plus scanners (Figure 2-15), use the internal ice-point reference. An RTD mounted inside each scanner measures the terminal junction temperature needed for internal ice-point referencing. Using temperature data provided by the RTD, Digi 4 Plus automatically computes the millivolt value of the ice point reference voltage for each thermocouple type and algebraically adds the proper value to the millivolt output of each measuring thermocouple. The assigned function code specifies the thermocouple type and corresponding reference voltage added. Specify Source 1 as 000. If you do not specify a value for Source 1, it automatically defaults to 000. See Section 5 for more information.

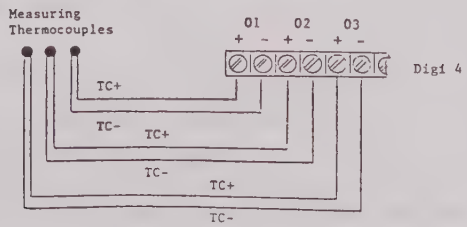


Figure 2-15. Thermocouple/Analog Plus Scanner Connections

Thermocouples/Automatic Ice Point Reference Connections

When connecting thermocouples to the input terminals of an automatic ice point reference such as the Kaye Model K-170 automatic ice point reference (Figure 2-16), the junctions where thermocouple leads are converted to copper are continually maintained at the ice point. The already compensated thermocouple output data is transmitted via copper leads to the input terminals of an Analog Plus scanner. Assign a channel or CALC channel address to Source 1. Program this address with a constant value of zero. A reference value of 0.0mV is agebraically added to the already referenced millivolt output of each measuring thermocouple. See Section 5 for more information.

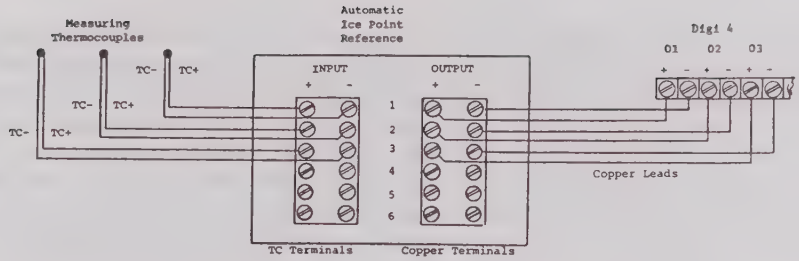


Figure 2-16. Thermocouple/Automatic Ice Point Reference Connections

Some automatic ice point references have shield terminals. With shielded wires, connect the shields to the shield terminals and ground the shields at either the temperature measuring or Digi 4 Plus end of each circuit.

Thermocouple/Uniform Temperature Reference Connections

When connecting a series of thermocouples of a particular type to the input terminals of a uniform temperature reference such as the X0280 uniform temperature reference (Figure 2-17), include a reference thermocouple of the same type in the series. Immerse the measuring junction of the reference thermocouple in an ice bath or automatic ice point reference; connect the output terminals of the universal temperature reference to the input terminals on the Analog Plus scanner with copper leads.

Source 1 of the function assigned to each measuring thermocouple input must be specified as the channel address to which the compensation input is directed. Source 1 of the function assigned to the compensation input must be specified as a constant with an output value of zero. The function code assigned the channel address to which the ice point reference is directed must be a voltage function that has the same voltage range as the thermocouple type. See Section 5 for more information.

Some uniform temperature references have shield terminals. If you use shielded wires, connect the shields to the shield terminals and ground the shields at either the temperature measuring or Digi 4 Plus end of each circuit.

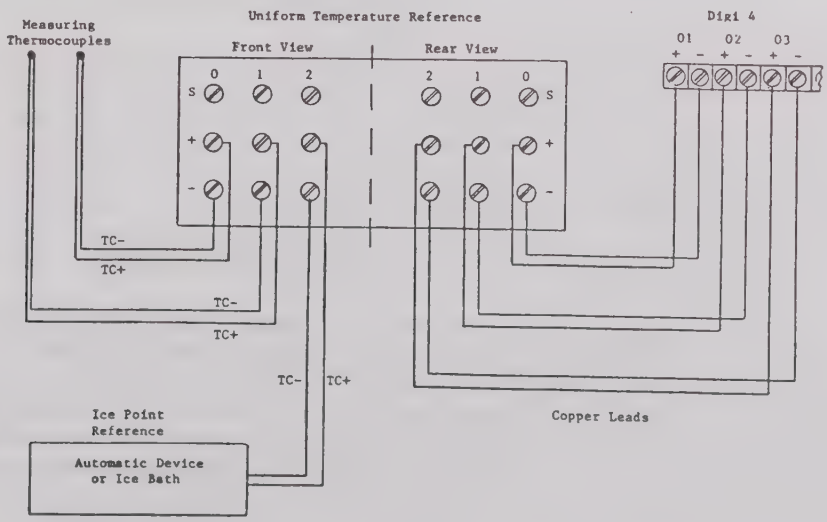


Figure 2-17. Thermocouple/Uniform Temperature Reference Connections

Resistive Devices

Digi 4 Plus can measure the resistance of resistance temperature detectors (RTD's). It scales variations in the measured resistance to provide temperature data in appropriate engineering units. Function Codes 039-046 provide non-linear scaling for the following standard RTD types:

- o 100 ohm platinum (0.01)
- o 100 ohm platinum (0.1)
- o 10 ohm copper (0.1)

RTD's are passive. Conditioning is required to produce a measurable output. When using 3-wire RTD's, connect the input leads directly to an RTD Plus scanner (Figure 2-18). Each scanner can condition up to 16 RTD's.

RTD's, strain gauges and other resistive devices also can be externally conditioned. Wire the outputs of externally conditioned resistive devices directly to Analog Plus scanners. Kaye manufactures a variety of equipment for external conditioning. Contact Kaye for more information.

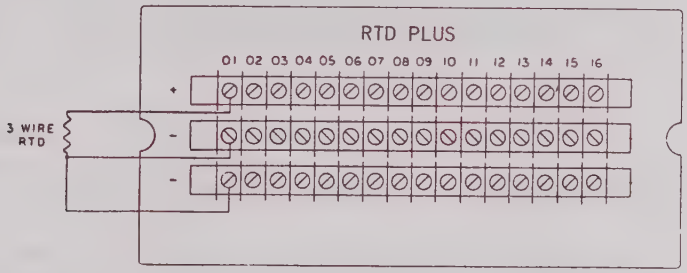


Figure 2-18. RTD Plus Scanner Connections

2.2.3 Connecting Status Inputs

When equipped with optional status input scanners, Digi 4 Plus can monitor the status of up to 32 digital inputs. Each status input indicates an on or off condition of an input. A voltage input signal is latched and sets the logic bit true. When the voltage drops to zero, the logic bit is reset to zero at the end of the next math scan. To make sure the system detects an off state, the contact must be open for two math scans. A contact must be closed a minimum of 30 milliseconds to turn the status input logic bit on.

A status input can be a logical source for variety of system operating routines. For example, a status input can initiate a data report printout or reset an accumulation function. See Section 6 for more information.

When a Digi 4 Plus monitors the status of one or more contacts, you must include status input scanners. Each scanner can monitor up to 16 status inputs. An external power supply provides power for the status inputs. Power can range from 24 to 48 VDC or VAC. Use Kaye's V2330 power supply panel (24VDC) or another suitable power supply.

Mount the scanners in the left spaces directly above the Interface I/O panel (Figures 2-2 and 2-3). Use a special cable if you mount them elsewhere. Figure 2-19 on the following page shows status input connections.

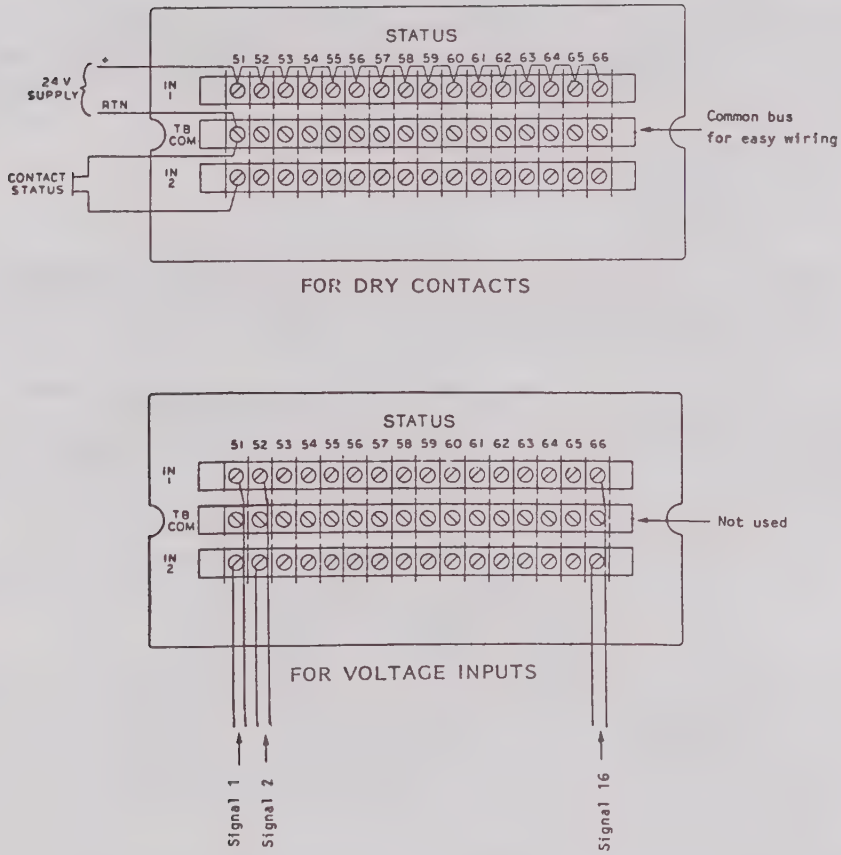


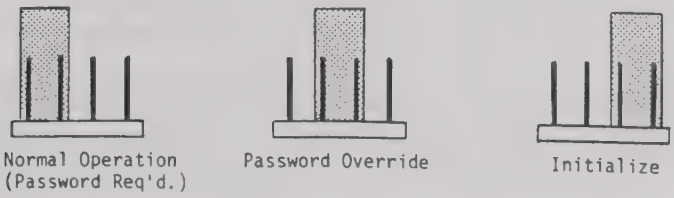
Figure 2-19. Status Input Connections

2.2.4 Initializing the System

Initialization clears Digi 4 Plus' memory of all program information and enters default values for selected parameters. Initialize the Digistrip 4 Plus when you receive your unit and before you enter a new program. You do not have to initialize the system when loading a program with the cassette program loader.

1. Connect Digistrip 4 Plus' power cord to a line voltage outlet, open the front door and power down. Slide the chassis forward on its rails.

2. Access the initialization jumper on the upper left corner of the Data acquisition board (4 Plus DA). Place the jumper in the INITLZ position (front 2 pins).



3. Power up. The display goes blank and there is a one second delay. A random dot pattern appears in the alphanumeric display and the system is initialized.
4. Place the jumper in the NORMAL position (back 2 pins).
5. Power down and up so Digistrip 4 Plus can read the DIP switch settings.
6. Access the Program mode, reset the system clock and enter a new program.

The PASS DIS position (middle 2 pins) is the password override. Place the jumper in this position only if you have to disable the password requirement to access the Program mode. Kaye does not recommend leaving the jumper in this position. See Section 10 (Configuration Codes 009 and 901) for more information. Set the system clock before programming the Digi 4 Plus.

2.2.5 Setting the System Clock

The Digistrip 4 Plus system clock keeps track of the current year, month, day, hour, minute and second. In addition, it controls all timed operations within the system. The system clock runs on a battery and continues to run if the power is off. Initialization is the only action, other than the passage of time, that changes settings of the system clock. When you initialize the system, the date and time registers are reset to zero. After initialization and at certain other times, you must reset the system clock to reflect the current date and time.

The date generated by the system clock keeps track of the number of days in each month (including the number of days in February until the year 2100). Use Configuration Code 006 to specify either European (DD/MM/YY) or American (MM/DD/YY).

Press the TIME key and the alphanumeric display contains the letter T (time), the upper display contains the month and day in the MM.DD format, and the lower display contains the current time in hours, minutes and seconds in the HH.MM.SS format. The display goes from 00.00.00 to 23.59.59, where 00.00.00 is midnight. The day advances on the transition from 23.59.59 to 00.00.00.

Press the TIME key again and the alphanumeric display contains a Y (year). The upper display contains the last two digits of the year.

Press the TIME key a third time and alphanumeric display contains a D (day-of-week). The upper display contains a single digit (1-7) that indicates a user-defined numerical day-of-the-week. For example, if you define day 1 as Sunday, Monday is day 2 and Saturday is day 7. You can use day-of-the-week information as an input for control functions.

To set the system clock, press the PROGRAM key to enter the Program mode. Enter the Program mode password, if required. (The front panel program indicator lights go on when you are in the Program mode.)

To set the time, press the TIME key. The alphanumeric display contains a T (time). The upper display contains the programmed month and day (MM.DD format) and lower display contains the programmed hours, minutes and seconds (HH.MM.SS format). Key in all the digits in the order they appear in the display (except seconds) and press the ENTER key. The seconds are shown as 00; you cannot change their value. To set the time exactly, press the ENTER key precisely on the minute.

To set the year, press the TIME key again. The alphanumeric display contains a Y (year) and the upper display contains the last two digits of the programmed year. Key in the last two digits of the year and press the ENTER key.

To set the day-of-week, press the TIME key a third time. The alphanumeric display contains a D (day-of-week). The upper display contains the programmed day-of-week. Key in the digit and press the ENTER key. For example, if you want Monday to be day 1 and it is presently Wednesday, enter a 3. Digi 4 Plus updates the day-of-week at midnight and returns to day 1 after day 7. The day-of-week is stored as a global system parameter at Channel Address 913.

2.2.6 Loading Paper

When you install Digistrip 4 Plus you must load paper and set the top-of-page. During operation you may have to load more paper or correct a paper jam.

Digistrip 4 Plus uses 11 x 81/2 inch fanfold impact paper with tear-off tractor feed edges (Part No. M0776). Make sure the Digistrip 4 Plus' power switch on and the LOAD/ RUN switch is up; then follow the directions below. See Figure 2-20 to identify components.

1. Open Digistrip 4 Plus' front door and slide the chassis forward.

2. Turn the power switch ON, and set the LOAD/RUN switch up. Remove any unused paper from the lower paper tray. Lift the FEED switch to advance the last printed page out of the printer.

3. Remove the printed pages from the upper paper tray and open the tractor guides.

4. Slide a new paper pack into the lower paper tray. Make sure the words "Kaye Instruments" are on the right and the red end-of-paper stripe is on the bottom.

5. Manually feed three sheets of paper behind the platen and upward over the paper guide. Begin by feeding the top corner of the first page between the platen and the printhead. While feeding the paper over the paper guide, slide the edges beneath the paper clips.

6. Place the paper over the tractor guides, under the copper foil static eliminator, under the paper guide bar and into the upper paper tray. Make sure that the pages with the words "Kaye Instruments" are facing up so the paper folds properly.

7. Set the top-of-page position by holding the FEED switch up until the perforations at the top of a page are visible above the platen.

8. Set the LOAD/RUN switch down so the printer defines the current paper position as the new top-of-page.

Paper Out or Paper Jammed

Whenever Digistrip 4 Plus detects no paper (PAPER OUT) or a jammed carriage motor (PAPER JAMMED), the printer stops and Logic Bit 097 turns true to indicate the printer needs service.

Top-of-Page Setting

When you set the LOAD/RUN switch (Figure 2-20) down, the printer automatically defines the current paper position as top-of-page. As long as the LOAD/RUN switch remains down, the printer automatically advances the paper to the next top-of-page after printing each full page (48 lines).

If you do not set the top-of-page properly, you can manually reset it. Simply set the LOAD/RUN switch up and hold the FEED switch up until the perforations at the top of a page are visible above the platen. Release the FEED switch and set the LOAD/RUN switch down.

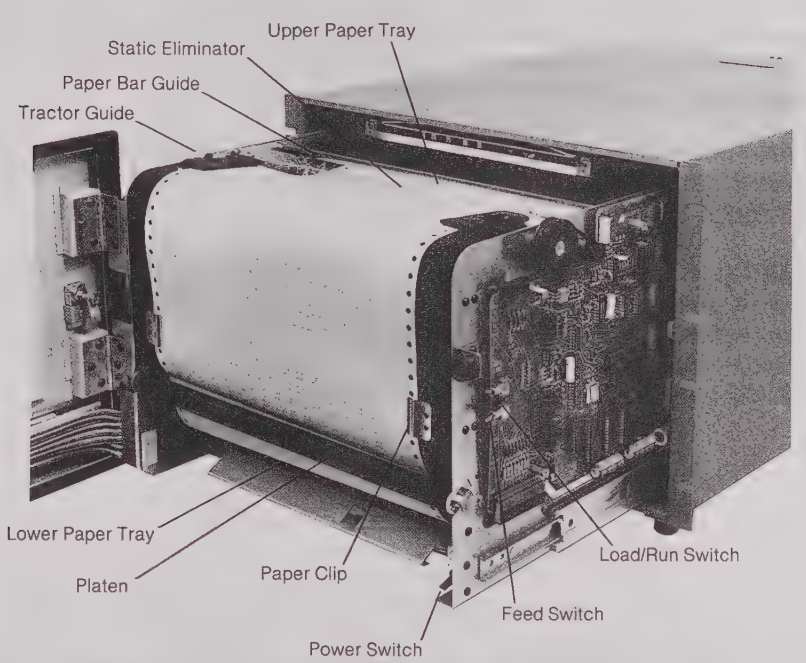


Figure 2-20. Digistrip 4 Plus Printer

2.2.7 Test Mode

The test mode checks system operations and provides a printed record of test information. During test mode, Digistrip 4 Plus does the following:

- o Prints the software level
- o Prints the complete character set
- o Prints an encoded representation of the internal switch settings
- o Performs relay switching tests

To access the test mode, hold the FEED switch up and turn the power switch from off to on while the LOAD/RUN switch is up. Test mode begins when you release the FEED switch. During test mode, Digistrip 4 Plus repeatedly prints a line containing the test information (Figure 2-21). To end the test mode, momentarily lift the FEED switch.

```
KAYE BEDFORD, MA U.S.A. D4LPT-V1.20 !"#%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^-`abcdefghijklmnopqrstuvwxyz{|} 3051
KAYE BEDFORD, MA U.S.A. D4LPT-V1.20 !"#%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^-`abcdefghijklmnopqrstuvwxyz{|} 3051
KAYE BEDFORD, MA U.S.A. D4LPT-V1.20 !"#%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^-`abcdefghijklmnopqrstuvwxyz{|} 3051
KAYE BEDFORD, MA U.S.A. D4LPT-V1.20 !"#%&'()*+,-./0123456789:;<=>?@ABCDEFGHIJKLMNOPQRSTUVWXYZ[\]^-`abcdefghijklmnopqrstuvwxyz{|} 3051
```

Software Level Character Set Switch Setting Code

Figure 2-21. Sample Test Mode Printout

2.3 INSTALLING A DIGI-LINK 4 PLUS

The Digi-Link 4 Plus is packaged in a NEMA enclosure. It contains an Interface I/O panel, an operator keyboard and display panel and a combination of scanners and peripherals. The NEMA enclosure has a centralized power distribution connection with built-in wire ducts keep the field wiring neat and accessible. All components and accessories (including the operator keyboard and display) are mounted inside the cabinet. Figures 2-22 through 2-25 show mounting configurations. See Appendix B of the Digi 4 Plus Maintenance Manual for NEMA enclosure dimensions.

For maximum operating reliability and accuracy, maintain the ambient temperature of the installation in the 0-50°C (32-125°F) range and do not let the relative humidity exceed 95% (non-condensing).

Each Digi-Link 4 Plus can accept a total of 128 analog and 32 status inputs. You can mount up to eight scanners (Analog Plus, RTD Plus or status input) in the standard NEMA enclosure. Each scanner accepts 16 inputs. Table 2-5 lists the scanner combinations. As an option, you can order a larger NEMA enclosure and mount all 10 scanners: eight Analog Plus and/or RTD Plus and two status input.

Table 2-5. Scanners in Standard NEMA 4

Status Input Scanners	2	1	1
Analog Plus and RTD Plus Scanners	1-6	1-7	1-8

Mounting configurations are flexible (Figures 2-22 through 2-26). The scanners fit into slots on a scanner mounting panel. Each scanner mounting panel can hold two scanners. You must mount status input scanners directly below the Interface I/O panel. (A 24 volt power supply built into the Interface I/O panel provides power for the status inputs.) You can mount Analog Plus and RTD Plus scanners in any available slot.

You can also mount the following peripherals inside the NEMA enclosure:

- Relay closure modules (SSRC-8 or RC-8R)
- D4 Output system (analog and relay modules)
- Frequency scanner (FS-8)
- Digital scanner (DS-8)
- Bridge conditioner (BC-8)
- Strain gauge conditioner (BC-8SSG)

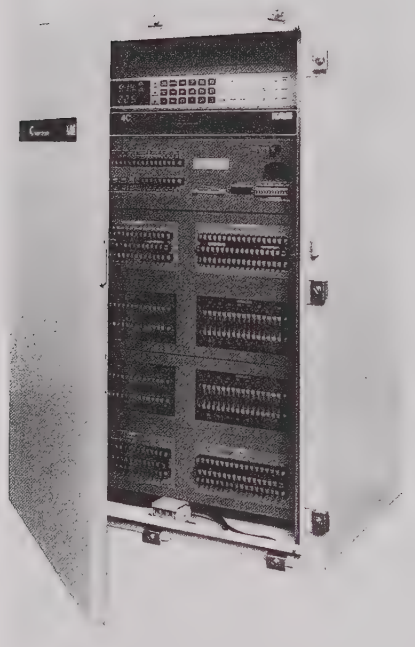


Figure 2-22. Digi-Link 4 Plus in Standard NEMA Enclosure

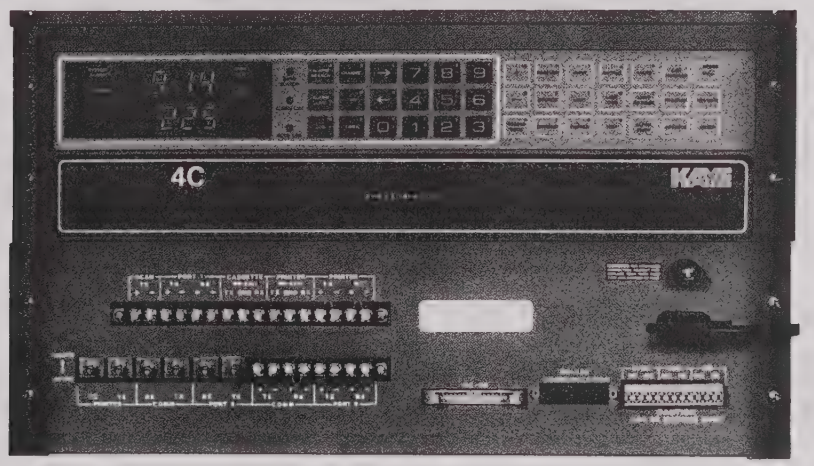


Figure 2-23. Digi-Link 4 Plus Display and Interface Panels

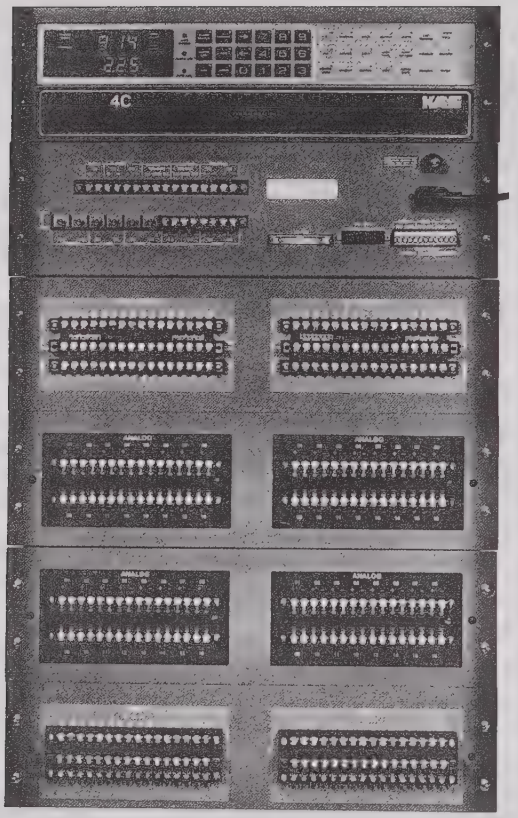


Figure 2-24. Digi-Link 4 Plus - Fully Populated

2.3.1 Connecting Peripherals

Connect peripherals to a Digi-Link 4 Plus in the same way as a Digistrip 4 Plus. See Section 2.2.1 for directions.

2.3.2 Connecting Analog Inputs

Connect analog inputs to a Digi-Link 4 Plus in the same way as a Digistrip 4 Plus. See Section 2.2.2 for directions.

2.3.3 Connecting Status Inputs

The Digi-Link 4 Plus has a built-in 24 volt power supply. Connect status inputs to a Digi-Link 4 Plus in the same way as a Digistrip 4 Plus. See Section 2.2.3 for directions.

2.3.4 Initializing the System

Initialization clears Digi-Link 4 Plus' memory of all user-programmed information and enters default values for selected parameters. Initialize the Digi-Link 4 when you receive your unit and before you enter a new program.

1. Power down. (Pull out the circuit breaker button or disconnect the power cord.)

2. Remove the four screws that secure the display panel assembly and slide the assembly forward. Access the initialization jumper on the right front corner of the Data Acquisition board (4 Plus DA) Place the jumper in the INITLZ position (left 2 pins).

Initialize | Password Override | Normal Operation (Password required)

3. Power up. The display goes blank and there is a one second delay. A random dot pattern appears in the alphanumeric display when the system is initialized.

4. Place the jumper in the NORMAL position (right 2 pins).

5. Power down and up once to let the system read the DIP switch settings.

6. Access the Program mode, reset the system clock and enter a new program.

The NO PASS position (middle 2 pins) is the password override. Place the jumper in this position only if it is necessary to disable the Program mode password. Kaye does not recommend leaving the jumper in this position. See Section 10 (Configuration Code Addresses 009 and 901) for more information. Set the system clock before programming the Digi 4 Plus.

2.3.5 Setting the system clock

Set the Digi-Link 4 Plus system clock in the same way as the Digistrip 4 Plus clock. See Section 2.2.5 for directions.

SECTION 3 - OPERATOR PANEL

3.1 GENERAL INFORMATION 3-1

3.2 KEYS 3-1

3.3 DISPLAYS AND INDICATOR LIGHTS 3-4

3.4 LIST PROGRAM 3-5

3.1 GENERAL INFORMATION

The Digi 4 Plus operator panel (Figure 3-1) contains a keyboard, three LED displays and seven status indicator lights. It is mounted on the front door of the Digistrip 4 Plus and on the display panel inside the Digi-Link 4 Plus NEMA enclosure.

Figure 3-1. Digi 4 Plus Operator Panel

When you power-on or power returns after an outage, Digi 4 Plus beeps every two seconds for 20 seconds, goes through its diagnostic sequence and then prints a power-on message (below). It displays the data at Channel 101. During an outage, an internal battery supports the Digi 4 Plus Plus' memory. The battery maintains the program for approximately two weeks.

RESTART AT: 12/05/86 11:32:28 (12/05/86 11:31:27) S5205 V1.00

Power On Time

Power Off Time

Memory Failure Diagnostic Code (if any failure)

Power On Date

Power Off Date

System Software Level

The system is not in the Program mode on power-up. To enter the Program mode, press the PROGRAM and ENTER keys. If required, enter the Program mode password.

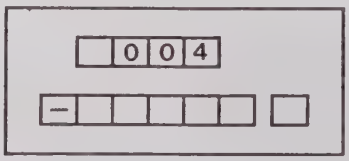
3.2 KEYS

The membrane keyboard has 39 pressure sensitive keys. With a few keystrokes you can:

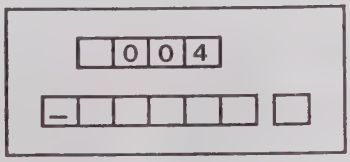
- Change timers
- Set the system clock
- View channel data
- Request reports
- Program the system
- List a program
- Access system and channel parameters
- Complete alphanumeric entries
- Restore or erase entries
- Search for limit tripped conditions
- Move forward or backward within a field
- Enter or leave the Program mode
- Copy data from one field to another

The number, symbol or legend in the middle of the key specifies its non-alpha shift mode. The letter or symbol at the upper right of the key specifies its alpha shift mode. Use the alpha shift mode to enter letters and symbols. Make all other keyboard entries in the non-alpha shift mode.

If a message or label contains letters and numbers, use both modes. To enter or exit the alpha shift mode, press the ALPHA SHIFT key. The horizontal bar at the left of the lower display indicates the mode: if it is at the bottom, Digi 4 Plus is in non-alpha shift mode; if it is in the center, Digi 4 Plus is in the alpha shift mode.



Alpha Shift Mode



Non-Alpha Shift Mode

Valid numeric entries must be in the +/-65535 range. If required, include leading zeros and a decimal point with numeric entries; the system automatically fills in trailing zeros. Precede negative entries with a minus (-) sign.

Key	Use
	ALPHA SHIFT MODE
Letter and symbol keys	Enter letters and symbols in messages, labels and units.
	NON-ALPHA SHIFT MODE
Number Keys (0-9)	Enter numbers in messages and labels; access addresses.
ADVANCE	Copy programmed information from one address to a higher numbered address (with the ENTER key).
ALPHA SHIFT	Select alpha shift or non-alpha shift mode.
ALARM LOG	Enable/disable automatic alarm log. It can generate an alarm status report if you assign Logic Address 094 to Configuration Code Address 050.
ALARM SEARCH	Search for channels in alarm and display the data; enable and disable auto search. Press twice to enable auto search. The Digi 4 Plus displays data for all channels in alarm at the rate of one channel per second. To disable auto search, press the twice rapidly.
BUFFER	Access Historical Buffer Addresses 01-16.
CHANNEL	Access channel addresses for review or programming.
CONSTANT	Access constant addresses for review or programming.
CONFIG CODE	Access a configuration code address for review or programming.
ENTER	Enter program data into the Digi's memory.

FUNCTION	Assign a function code to a channel address.
INPUT	Access the Input 1 and Input 2 storage registers at a channel address.
LIMIT	Access Limit 1 and Limit 2 at a channel address.
LIMIT OP-CODE	Access op-code parameters to specify limit action.
LIMIT TYPE	Select the limit type (high, low, rate-of-change).
LIST PROGRAM	Generate a list of programmed data.
LOG	Enable and disable auto log; generate reports.
	To enable or disable auto log, press twice rapidly. When auto log is enabled, the AUTO LOG indicator light is on.
	Generates a report if you assign Logic Address 091 to Configuration Code Address 010, 020, 030 or 040.
NULL	Delete programmed data or erase an invalid entry from the display (with the ENTER key).
OUTPUT	Access Output 1 and Output 2 parameters at a channel address.
PROGRAM	Switch the system in and out of the Program mode.
RESTORE	Restore data to the display if you have not pressed the ENTER key.
SOURCE	Access Source 1 and Source 2 at a channel address.
TEXT	Access text addresses to program messages and labels or for review.
TIME	Set the current date and time for the system clock.
TIMER	Set the time interval and reset time for system timers.
UNITS	Enter a single character units identifier with channel data.
→	Move the display from one address to the same parameter at the next higher address.
←	Move the display from one address to the same parameter at the next lower address.
•	Enter decimals in numeric data and periods in messages and labels.
–	Specify negative values; enter dashes in messages and labels.

3.3 DISPLAYS AND INDICATOR LIGHTS

The three LED displays and seven indicator lights provide data and system status information (Figure 3-2). A beeper indicates acceptance or rejection of an entry and alarm conditions.

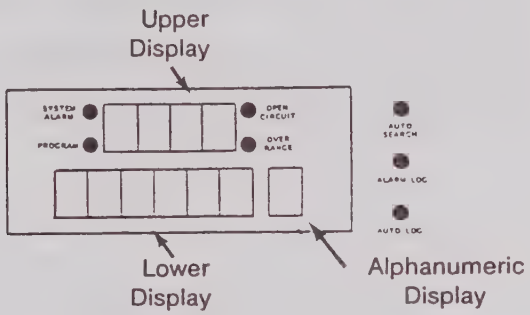


Figure 3-2. Displays and Indicator Lights

LED Displays

The Upper Display contains addresses.

The Lower Display contains data.

The Alphanumeric Display contains the individual characters of messages, labels and units designations. It also has letters that identify the parameter accessed. For example, it shows an F when you press the FUNCTION key.

Indicator Lights

The System Alarm Indicator goes on when a limit is tripped at one or more channels.

The Program Indicator goes on when Digi 4 Plus is in the Program mode from the operator panel. Auto exit takes it out of the Program mode if you do not use the keyboard for one hour.

If the Digi 4 Plus is placed in the Program mode from a computer, the Program indicator flashes. If a computer tries to enter the Program mode and the Digi 4 Plus is already in the Program mode from the operator panel, the Digi 4 Plus yields the Program mode to the computer. When the computer completes its programming, the Digi 4 Plus returns to the Program mode.

The Open Circuit Indicator goes on when an open circuit occurs at a channel.

The Over-range Indicator goes on when an over-range occurs at a channel.

The Auto Search Indicator goes on when auto search is active.

The Alarm Log Indicator goes on when alarm log is active.

The Auto Log Indicator goes on when auto log is active.

Beeper

A Single Short Beep indicates a valid entry.

A Long Beep indicates an invalid entry. Press the NULL key before reentering the correct data.

A Series of Short Beeps indicates an alarm. Press any key to turn the beeper off. To increase or decrease the volume, adjust the beeper volume control pot (behind the front door of the Digistrip 4 Plus and behind the display panel of the Digi-Link 4 Plus).

3.4 LIST PROGRAM

The LIST PROGRAM key generates the following parameter listings:

- Channels
- CALC channels
- Configuration codes
- Constants
- Messages
- System timers
- Historical buffers
- Relay latch states
- Sequencer parameters (Digi 4C Plus only)

You can request a complete set of listings or select listings individually. You cannot cancel a listing after requesting it.

For a complete program listing:

- Enter the Program mode.
- Press the CONFIG CODE key and enter 999.
- Press the LIST PROGRAM key.
- Press the ENTER key.

The following pages contain keying sequences and sample program listings. The date/time of the printout is in the upper right corner. These listings are printed in a 132-character format. You can also specify a 72-character format. See Configuration Code Address 004 for more information.

Channel and CALC Channel Parameters

Figure 3-3 shows a listing of channel parameters. They include: channel address (CHN); channel label (LABEL); function code (FN); decimal code (DECIMAL); Source 1 and Source 2 (SOURCES); Input 1 (IN1); Input 2 (IN2); Output 1 (OUT1); Output 2 (OUT2); units (UNITS); Limit 1 (LIM1); Limit 2 (LIM2); Limit Type (TYP) and Limit Op-Codes 1, 2 and 3 (OP1, OP2, and OP3) for Limits 1 and 2.

Use Sequence A to list all channel and CALC channel parameters. Use a variation of Sequence B to list selected channel and CALC channel parameters. Figure 3-3 on the following page lists parameters for Channels 101-316.

Sequence A

CHANNEL | LIST PROGRAM | ENTER

Display

0 0 1. 8 1 6

Sequence B

CHANNEL | LIST PROGRAM | 1 | 0 | 1

3 | 1 | 6 | ENTER

Display

1 0 1. 3 1 6

CHANNEL PARAMETERS 03/27/88 20:50:19

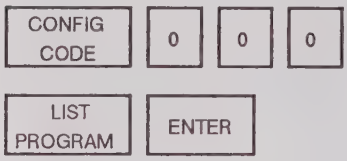
CHN	LAB	FN	DEC	SOURCES	IN1	IN2	OUT1	OUT2	U	LIM1	TYP	OP1	OP2	OP3	LIM1	TYP	OP1	OP2	OP3
101		016	0.0	... 000	0.2500	1.2500	50.0	150.0	F	90.0	H	000100	000000	002900	122.0	H	000100	000000	002800
102		016	0.0	... 000	0.2500	1.2500	50.0	150.0	F	0.0	L	000100	000000	002700	130.0	H	000100	000000	002600
103		016	0.0	... 000	0.2500	1.2500	0.0	100.0	F	44.0	L	000100	000000	003100	55.0	H	000100	000000	000300
104		016	0.0	... 000	0.2500	1.2500	0.0	4000.0	A	0.0	L	000100	000000	002500	....	H	000000	000000	000000
105		016	0.0	... 000	0.2500	1.2500	50.0	100.0	K	...	H	000000	000000	000000	....	H	000000	000000	000000
106		016	0.0	... 000	0.2500	1.2500	50.0	100.0	K	...	H	000000	000000	000000	....	H	000000	000000	000000
107		016	0.0	... ...	.....	.....	....	.....	F	...	H	000000	000000	000000	....	H	000000	000000	000000
108		016	0.0	... ...	.....	.....	....	.....	F	...	H	000000	000000	000000	....	H	000000	000000	000000
109		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
110		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
111		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
112		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
113		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
114		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
115		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
116		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
201		016	0.0	... 000	0.2500	1.2500	50.0	150.0	F	90.0	H	000100	000000	002900	122.0	H	000100	000000	002800
202		016	0.0	... 000	0.2500	1.2500	50.0	150.0	F	0.0	L	000100	000000	002700	130.0	H	000100	000000	002600
203		016	0.0	... 000	0.2500	1.2500	0.0	100.0	F	44.0	L	000100	000000	003100	55.0	H	000100	000000	000300
204		016	0.0	... 000	0.2500	1.2500	0.0	4000.0	A	0.0	L	000100	000000	002500	....	H	000000	000000	000000
205		016	0.0	... 000	0.2500	1.2500	50.0	100.0	K	...	H	000000	000000	000000	....	H	000000	000000	000000
206		016	0.0	... 000	0.2500	1.2500	50.0	100.0	K	...	H	000000	000000	000000	....	H	000000	000000	000000
207		016	0.0	... ...	.....	.....	....	.....	F	...	H	000000	000000	000000	....	H	000000	000000	000000
208		016	0.0	... ...	.....	.....	....	.....	F	...	H	000000	000000	000000	....	H	000000	000000	000000
209		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
210		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
211		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
212		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
213		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
214		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
215		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000
216		016	0.0	... ...	.....	.....	....	.....		...	H	000000	000000	000000	....	H	000000	000000	000000

Figure 3-4. Channel Parameter Listing

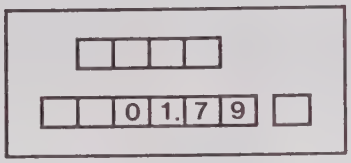
Configuration Codes

Figure 3-4 shows a listing of configuration codes. It contains Configuration Codes 001-079. Use the sequence below for this listing. See Section 10 for more information.

Keystrokes



Display



CONFIGURATION CODES 03/27/88 20:50:19

	000	010	020	030	040	050	060	070
0		000601	000415	000000	000000	000000	000000	000000
1	120000	000000	000000	000000	000000	000000	000000	000000
2	000000	010101	000000	000000	000000	000000	000000	000000
3	010000	000000	000000	000000	000000	000000	000000	000000
4	480000	113910	000000	000000	000000	000000	000000	000000
5	120000	094100	000000	000000	000000	000000	000000	000000
6	000000	300010	000000	000000	000000	000000	000000	000000
7	177770	000000	000000	000000	000000	000000	000000	000000

Figure 3-4. Configuration Code Listing

Constants

Figure 3-5 shows a listing of constants. It contains the input and output values for Constant Addresses 01-99. Use the sequence below for this listing. See Section 6 for more information.

Keystrokes	Display
CONSTANT LIST PROGRAM ENTER	01.99

CONSTANTS 03/27/88 20:50:19

CONST	INPUT	OUTPUT	CONST	INPUT	OUTPUT	CONST	INPUT	OUTPUT
01	.....	125	34	.....	.....	67	.....	.....
02	.....	.....	35	.....	.....	68	.....	.....
03	.....	.....	36	.....	.....	70	.....	.....
04	.....	.....	37	.....	.....	71	.....	.....
05	.....	.....	38	.....	.....	72	.....	.....
06	.....	.....	39	.....	.....	73	.....	.....
07	.....	.....	40	.....	.....	74	.....	.....
08	.....	.....	41	.....	.....	75	.....	.....
09	.....	.....	41	.....	.....	76	.....	.....
10	.....	.....	43	.....	.....	77	.....	.....
11	.....	.....	44	.....	.....	78	.....	.....
12	.....	.....	45	.....	.....	79	.....	.....
13	.....	.....	46	.....	.....	80	.....	.....
14	.....	.....	47	.....	.....	81	.....	.....
15	.....	.....	48	.....	.....	82	.....	.....
16	.....	.....	49	.....	.....	83	.....	.....
17	.....	.....	50	.....	.....	84	.....	.....
18	.....	.....	51	.....	.....	85	.....	.....
19	.....	.....	52	.....	.....	86	.....	.....
20	.....	.....	53	.....	.....	87	.....	.....
21	.....	.....	54	.....	.....	88	.....	.....
22	.....	.....	55	.....	.....	89	.....	.....
23	.....	.....	56	.....	.....	90	.....	.....
24	.....	.....	57	.....	.....	91	.....	.....
25	.....	.....	58	.....	.....	92	.....	.....
26	.....	.....	59	.....	.....	93	.....	.....
27	.....	.....	60	.....	.....	94	.....	.....
28	.....	.....	61	.....	.....	95	.....	.....
29	.....	.....	62	.....	.....	96	.....	.....
30	.....	.....	63	.....	.....	97	.....	.....
31	.....	.....	64	.....	.....	98	.....	.....
32	.....	.....	65	.....	.....	99	.....	.....
33	.....	.....	66	.....	.....	67	.....	.....

Figure 3-5. Constant Listing

Messages

Figure 3-6 shows a listing of messages. It contains Messages 00-99 (programmed at Text Addresses 000-099). Use the sequence below for this listing. See Section 8 for more information.

Keystrokes

TEXT | LIST PROGRAM | ENTER

Display

0 0. 9 9

MESSAGES 03/27/88 20:50:19

ADDR	MESSAGE	ADDR	MESSAGE	ADDR	MESSAGE
01	PREVAC STARTED	34		67	
02	PREVAC DONE - RAMP TO 109.8C	35		68	
03	RAMP DONE - RAMP TO EXPOSE TEMP	36		69	
04	EXPOSURE DONE - START EXHAUST	37		70	
05	EXHAUST DONE	38		71	
06	DRY TIME STARTED	39		72	
07	DRY TIME DONE - START RELIEF	40		73	
08	CYCLE COMPLETE	41		74	
09		42		75	
10		43		76	
11	*WARNING* PROGRAM HAS CHANGED	44		77	
12	PROGRAM CHANGE DOCUMENTED	45		78	
13		46		79	
14	PROCESS ABORTED	47		80	
15	ABORT COMPLETED	48		81	
16		49		82	
17		50		83	
18		51		84	
19		52		85	
20		53		86	
21		54		87	
22		55		88	
23		56		89	
24		57		90	
25		58		91	
26		59		92	
27		60		93	
28		61		94	
29		62		95	
30		63		96	
31		64		97	
32		65		98	
33		66		99	

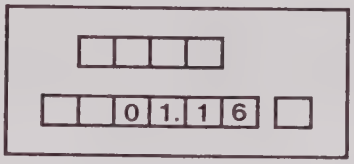
Figure 3-6. Messages Listing

System Timers

Figure 3-7 shows a listing of system timers. It contains the intervals and reset times for Timers 01-16. Use the keying sequence below for this listing. See Section 6 for more information.

Keystrokes

Display



TIMERS

03/27/88 20:50:19

TIMER ADDRESS	INTERVAL DD:HH:MM:SS	RESET TIME DD:HH:MM:SS
01	05:00:00:00	00:00:00:00
02	00:00:00:00	00:00:00:00
03	00:00:00:00	00:00:00:00
04	00:00:00:00	00:00:00:00
05	00:00:00:00	00:00:00:00
06	00:00:00:00	00:00:00:00
07	00:00:00:00	00:00:00:00
08	00:00:00:00	00:00:00:00
09	00:00:00:00	00:00:00:00
10	00:00:00:00	00:00:00:00
11	00:00:00:00	00:00:00:00
12	00:00:00:00	00:00:00:00
13	00:00:00:00	00:00:00:00
14	00:00:00:00	00:00:00:00
15	00:00:00:00	00:00:00:00
16	00:00:00:00	00:00:00:00

Figure 3-7. System Timer Listing

Historical Buffers

Figure 3-8 shows a listing of historical buffers. It contains Source 1 (channel address) and Source 2 (logic address) information for Historical Buffers 01-16. Use the keying sequence below for this listing. See Section 6 for more information.

Keystrokes

BUFFER | LIST PROGRAM | ENTER

Display

0 1. 1 6

BUFFERS 03/27/88 20:50:19

BUFFER ADDRESS	SOURCE 1 CHANNELS	SOURCE 2 LOGIC
O1	000	000
02	000	000
03	000	000
04	000	000
05	000	000
06	000	000
07	000	000
08	000	000
09	000	000
10	000	000
11	000	000
12	000	000
13	000	000
14	000	000
15	000	000
16	000	000

Figure 3-8. Historical Buffer Listing

Relay Latch States

Figure 3-9 shows a listing of programmed relay latch states listing. It contains the latching states for Relays 01-48. Use the keying sequence below for this listing. See Section 11 for more information.

Keystrokes				Display
CONFIG CODE	1	0	0	
LIST PROGRAM	ENTER			0 1. 4 8

RELAY LATCH STATES 03/27/88 20:50:19

RELAY	1 = LATCHING / 2 = NON-LATCHING							
01 - 08	0	0	0	0	0	0	0	0
09 - 16	0	0	0	0	0	0	0	0
17 - 24	0	0	0	0	0	0	0	0
25 - 32	0	0	0	0	0	0	0	0
33 - 40	0	0	0	0	0	0	0	0
41 - 48	0	0	0	0	0	0	0	0

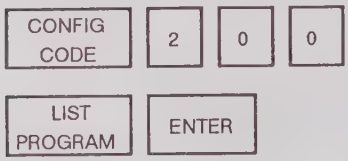
Figure 3-9. Relay Latch States Listing

Sequencer Parameters

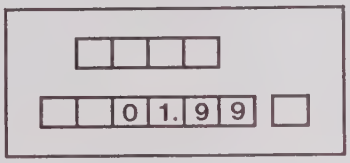
Figure 3-10 shows a listing of sequencer parameters (Function Code 150). Parameters for each sequencer address (ADDR) include: continue flag (CONT), base message address (MSG), match address (MA), non-match address (NMA), 16 status inputs, 16 relay outputs, Source 1 with the state of its logic bit (1 .L), and Source 2 with the state of its logic bit (2 .L).

Use Sequence A for a complete listing (Sequencer Addresses 01-99). Use a variation of Sequence B for a partial listing. The example specifies parameters for Sequencer Addresses 01-16. See Section 5 for more information.

Sequence A

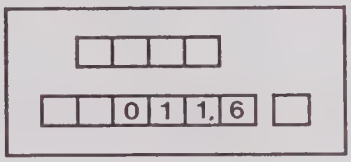


Display



Sequence B

Display



SEQUENCER 03/27/88 20:50:19

ADR	MSG	NMA	RELAY OUTPUTS				STATUS INPUTS				SOURCES	
CONT	MA		01	05	09	13	51	55	59	63	1 .L	2 .L
01	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
02	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
03	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
04	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
05	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
06	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
07	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
08	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
09	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
10	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
11	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
12	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
13	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
14	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
15	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1
16	00.00.00		0000	0000	0000	0000	—	—	—	—	000.1	000.1

Figure 3-10. Sequencer Parameter Listing

SECTION 4 - CHANNEL ASSIGNMENTS

4.1 GENERAL INFORMATION 4-1

4.2 CHANNEL OUTPUT DATA 4-2

4.3 CHANNEL ASSIGNMENTS 4-4
- 4.3.1 Function and Decimal Codes 4-4
- 4.3.2 Sources 4-5
- 4.3.3 Input and Output Values 4-7
- 4.3.4 Limits 4-9
- 4.3.5 Limit Operation Codes 4-10
- 4.3.6 Engineering Units 4-10
- 4.3.7 Labels 4-10

4.4 OUTPUTTING A CONSTANT 4-11

4.5 COPYING ASSIGNMENTS 4-11

4.1 GENERAL INFORMATION

Digi 4 Plus has 128 fixed format locations called channels. They form a matrix of 8 rows by 16 columns (Figure 4-1). Each channel has a three-digit identifier, called the channel address. The first digit identifies the row; the last two digits identify the column. For example, channel address 314 accesses the data stored at column 14 of row 300.

	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16
100	101	102	103													116
200	201															
300	301															
400																
500																
600																
700																
800																816

Figure 4.1. Channel Matrix

You must assign a function code before Digi 4 Plus can accept, process or monitor input data at a channel. The function code specifies the exact operation Digi 4 Plus performs on input data and determines additional parameters used. These parameters include:

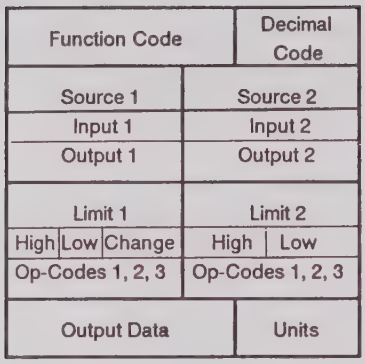
- o Resolution of output data (decimal code)
- o Source data
- o Input and output constants
- o Limits and limit op-codes
- o Units

You can also include a label with the output data at each channel address.

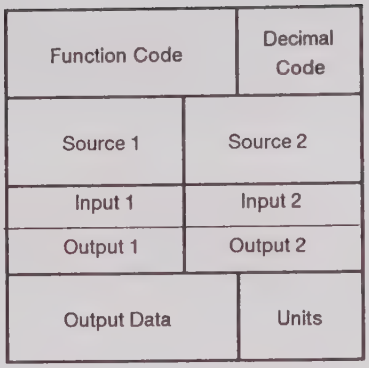
Figure 4-2 on the following page shows the channel parameters.

Digi 4 Plus also has 99 locations called calculation channels (CALC channels), numbered consecutively from 001 to 099. As their name indicates, they are used for calculations. They do not accept function codes that process live input, output logical data or print one line messages. See Section 4.3.1 for more information.

CALC channels do not accept limits or limit op-codes and you can not include data from CALC channels in a report.



Channels



CALC Channels

Figure 4-2. Parameters

If a function code uses multiple channels, they must be all be the same type (channels or CALC channels).

4.2 CHANNEL OUTPUT DATA

There are three kinds of output data: displayed, logical and extended precision. All defined channels output displayed and logical data. All defined CALC channels output displayed data. Depending on the function code, channels and CALC channels can also output extended precision data.

Displayed Data

Displayed data is the numerical data stored at a channel, CALC channel, constant or historical buffer. The decimal location in displayed output data is either fixed by the function code or user-defined. The decimal cannot appear in the left-most position. Displayed data must conform to the following constraints:

+/-65535, +/-65535., +/-6553.5, +/-655.35, +/-65.535 or +/-6.5535

The least significant digit is a result of rounding. If the display capacity is exceeded, an over-range occurs. For example, 79123., -9976.3 and 8.4432 are over-range

To display output data, press the CHANNEL key and enter address or press the INCREMENT or DECREMENT key.

Logical Data

Logical data is the state of the channel logic bit. Each channel stores a logic bit that specific actions can turn on or off. When a logic bit is on, it is true; when it is off, it is false. The assigned function code determines the actions that turn a channel logic bit on and off.

For most function codes, the channel logic bit is turned on if the assigned limit is exceeded or if the channel output data is open circuit or over-range.

A channel logic bit can be used as input data to another channel if its function code accepts logical input data. It can also generate a report or release data stored in the text output buffer.

With certain function codes, such as the Boolean functions, the logical operation performed on the input data controls the channel logic bit. When the channel output data is true, 1.00 is displayed and the channel logic bit is turned on. When the channel output data is false, 0.00 is displayed and the channel logic bit is turned off.

To view the state of a channel logic bit, press the CHANNEL key and enter the address. When the logic bit is true, a decimal point precedes the channel address. When it is false, the space preceding the channel address is blank.

Extended Precision Data

Extended precision data is the numerical data at a channel that is not restricted by the +/-65535 display capacity. The magnitude and resolution of extended precision data is approximately $+/-9.223372 \times 10^{+/-18}$.

Extended precision data is stored internally and not displayed. It minimizes the loss of significant digits and increases the dynamic range of the data. Depending on the assigned function code, a channel or CALC channel can output extended precision data in addition to displayed data. See the function charts in the Digi 4 Plus Quick Reference for more information.

Extended precision data may still be valid if the displayed data is over-range.

Example: The result of a calculation at Channel 101 is 100,000. Because 100,000 exceeds the display capacity, Channel 101 is over-range. If its function code generates extended precision data, 100,000 is stored internally and can be used by a channel that accepts extended precision inputs.

Example: The result of a calculation at Channel 102 is 0.000038. The best resolution of displayed data is 0.0000. If its function code generates extended precision data, 0.000038 is stored internally and can be used by a channel that accepts extended precision inputs.

Extended precision data is useful in calculations that involve multiple channels. If an intermediate result is over-range or the displayed data does not express the full resolution of the data, a channel that accepts extended precision inputs can use that channel's extended precision value.

Example: Assign Function Code 086 (multiplication function) to Channel 103. Math functions accept extended precision inputs. Source 1 is Channel 101 and Source 2 is Channel 102. The extended precision value of the sources is 100,000 and 0.000038. The result of the calculation (3.8) is displayed at Channel 103, even though the intermediate results at the source channels are over-range and 0.0000, respectively.

4.3 CHANNEL ASSIGNMENTS

The Digi 4 Plus must be in the Program mode to enter a function code or decimal code at a channel address. The operator accesses the Program mode by entering the correct Program password. Configuration Code Address 901 stores the Program mode password.

For additional security, Configuration Code Address 009 lets you restrict other channel parameters to the Program mode. However, Configuration Code Address 009 only secures the parameters to the Program mode from the operator panel. A computer is still allowed access to these parameters through the CXT protocol. For example, if channel limits are secured to the Program mode, an operator has to enter the Program mode password before changing the limit. However, the KVIEW workstation can make the same change without placing the Digi 4 Plus in the Program mode.

All scanning, alarming and output operations continue while Digi 4 Plus is in the Program mode.

Digi 4 Plus also lets you copy assignments from one channel to another. The copy feature saves time and decreases entry error. See Section 4.5 for more information.

4.3.1 Function and Decimal Codes

When the system is initialized, Function Code 000 (skip function) is automatically assigned to Channels 201-816 and all CALC channels. This means no data is processed at these addresses until you assign a non-zero function code.

Function Codes

A function code specifies the computational routine Dig 4 Plus performs on channel input data. See Section 5 or the Function Overview Chart in the Digi 4 Plus Quick Reference for more information.

Channels accept all function codes. CALC channels do not accept the following:

- o System input functions (001-050)
- o Accumulation functions that output a single line of data (056-058)
- o Meter function (059)
- o Boolean functions (101-107)
- o Flip-flop functions (108-111)
- o Data compare functions (112-113)
- o Control counter function (123)
- o Track-and/or-hold functions (148-149)
- o Sequencer function (150)

If input data (voltage, RTD or thermocouple) comes from a sensor directly connected to a Digi 4 Plus terminal bank, use the corresponding voltage or sensor function code. If input data comes from another channel, constant or historical buffer address, use the appropriate function code; for example, linearization, square root or accumulation.

Assign the function code before you enter other parameters. When you enter a function code, existing parameters are nulled. To restore limits, press the LIMIT TYPE and ENTER keys.

Decimal Codes

A decimal code defines the resolution of the displayed data. Certain function codes, such as voltage, thermocouple and RTD, implicitly specify the decimal location. Others have a default decimal location you can redefine.

To access the decimal code, press the FUNCTION key twice. The alphanumeric display contains a D (decimal code); the lower display contains zeros and a decimal. To redefine the decimal, key in zeros with the decimal in the position you want. If you cannot redefine the decimal, a minus sign precedes the zeros.

Decimal Code	Display Capacity
0.0000	+/-6.5535
00.000	+/-65.535
000.00	+/-655.35
0000.0	+/-6553.5
00000.	+/-65535.

For example, if 00000. is the default decimal location, you can change the resolution of the displayed output data from 00001. to 00.001 by assigning 00.000 to the decimal code.

When you redefine a decimal code, limits at that channel are nulled (CALC channels do not accept limits). To restore limit values, press the LIMIT TYPE and ENTER keys.

To assign a function code:

- Press the PROGRAM key. Enter the password if required. Press the ENTER key.
- Key in the address.
- Press the FUNCTION key and key in the function code. Press the ENTER key.

The upper display contains the address, the lower display contains the function code and the alphanumeric display contains an F (function code). To view function codes at other channels, press the INCREMENT or DECREMENT key.

To view the decimal code, press the FUNCTION key again. The alphanumeric display contains a D (decimal code) and the lower displays contains the decimal location. A minus sign indicates the decimal cannot be redefined.

4.3.2 Sources

A source is a three-digit number that specifies the location of channel input data. A function code may require numerical input data, logical input data, or both. Function Codes 001 to 050 (system input) require input from a sensor directly connected to Digi 4 Plus or to a remote scanner. The function code determines the number of sources (0, 1 or 2) and their type.

Numerical data is stored at a channel, constant, historical buffer or global system parameter address. Logical data, zero or one, is stored at a logic address. Table 4-1 on the following page lists Digi 4 Plus source addresses. See Section 6 for more information.

Table 4-1. Sources

Numerical Data	Addresses
System input (implied source)	000
CALC channels	001-099
Channels	101-816
Global system parameters	901-916
Historical buffers	001-016
Number of buffer entries (Historical buffer functions only)	001-032
Constants (Multi-segment and polynomial functions only)	001-099

Logical Data	Addresses
Always true logic bit	000
Relay logic bits	001-048
Odd master relay logic bit	049
Even master relay logic bit	050
Status input logic bits	051-082
Analog scan logic bit	083
Power-on logic bit	084
Set by terminal/computer	085-088
Program altered	090
LOG key/operator panel	091
Command 110 from computer	092
OR of 091 and 092	093
ALARM LOG/operator panel	094
Command 111 from computer	095
OR of 094 and 095	096
Printer needs service	097
Printer off-line	098
Always false logic bit	099
Channel logic bits	101-816
System timer logic bits	901-916

When you assign a source, Digi 4 Plus checks to make sure it is valid, but does not check to make sure that it is correct for your program. If you do not assign a valid system source, Digi 4 Plus emits a long beep and rejects the entry.

System Input Data

System input data comes from a sensor connected directly to the terminal bank of a Digi 4 Plus input scanner or from an external scanner such as a DS-8, FS-8 or Digi-Link 4 Plus. Function Codes 001-050 (voltage, linear, thermocouple, RTD and multi-segment linear functions) are system input function codes.

When you assign a function code that accepts system input data, an open circuit occurs if you do not direct system input data to that channel. If data comes directly from a Digi 4 Plus Analog Scanner, Configuration Code Address 001 or 002 must specify the row of channel addresses that receive the data. See Section 10 for more information.

If the system input data comes from an external scanner, Digi 4 Plus must receive a reading every 20 seconds from a scanner directed to that channel address or an open circuit occurs. See your external scanner documentation for more information.

Numerical Input Data

There are two types of numerical input data: displayed and extended precision. Some function codes require displayed data to complete their computational routines. Others use displayed data if extended precision data is it not available.

Displayed Data is stored at a channel, CALC channel, constant, historical buffer or global system parameter address. Its decimal is either fixed by the assigned function code or defined in the decimal code. Displayed data must conform to the following constraints:

+/-65535, +/-65535., +/-6553.5, +/-655.35, +/-65.535 or +/-6.5535

Extended Precision Data is stored internally at a channel or CALC channel if the function code generates extended precision data. Extended precision data minimizes the loss of significant digits and increases the dynamic range of the data; it is not restricted by the +/-65535 capacity. Its magnitude and resolution is $9.223372 \times 10^{+/-18}$.

Extended Precision Data has greater resolution than displayed data and is available in the background even if displayed data is over-range.

Logical Input Data

All defined channels (but not CALC channels) store logical data as a channel logic bit. Logic Addresses 101-816 store the state of the channel logic bit.

There are 116 system logic bits in addition to the logic bits at each channel address. Logic Addresses 000-099 and 901-916 store the system logic bits. Both channel logic bits and system logic bits can be used as input to a channel that accepts logical inputs. See Section 6 for more information.

To view the state of a logic bit, press the CHANNEL key and enter the logic address. If the logic bit is true, a decimal precedes the address. If it is false, the space preceding the address is blank.

To assign a source:

- Key in the channel address and press the SOURCE key. The upper display contains a 1 (Source 1) to the left of the channel address.

  If the assigned function code does not use Source 1, the lower display contains three dashes.

  If you previously defined Source 1, it contains that value.

  If you have not defined Source 1, it contains three zeros.
- Key in a three-digit value and press the ENTER key.
- Press the SOURCE key again. The upper display contains a 2 (Source 2) to the left of the channel address.

  If the assigned function code does not use Source 2, the lower display contains three dashes.

  If you previously defined Source 2, it contains that value.

  If you have not defined Source 2, it contains three zeros.
- Key in a three-digit value and press the ENTER key.

To view sources at other channels, press the INCREMENT or DECREMENT key.

4.3.3 Input and Output Values

Each channel and CALC channel has four registers that store values: Input 1, Input 2, Output 1 and Output 2. Depending on the function code, these values can be user-defined or automatically entered by the system. The names reflect their primary use: to specify the two points that define linear scaling computation of Function Codes 006-017 (linear input) and Function Codes 051-053 (linear transfer). See Section 5 for more information.

The values assigned these registers must conform to the following display capacity and resolution constraints:

+/-65535., +/-6553.5, +/-655.35, +/-65.535 or +/-6.5535

The input/output registers contain parameters required by the function code. If you do not assign a value to a required input/output parameter, an over-range occurs.

For Function Codes 082 to 175 (except Function Codes 116 and 117), the system uses the constant stored in Input 1 if Source 1 is 000. It uses the constant stored in Input 2 if Source 2 is 000.

Source 1 data is stored at Input 1; Source 2 data is stored at Input 2. To view the current value of source data, press the corresponding INPUT key. If the display for Input 1 or Input 2 is blank, data at Source 1 and/or Source 2 is open, over-range or nulled.

Decimals in input/output values are usually user-defined. However, Digi 4 Plus assigns the decimal in the Input 1 value with a linear input function.

To assign Input 1 and Input 2:

- Key in the channel address and press the INPUT key. The alphanumeric display contains an I (input) and the upper display contains a 1 (Input 1).

  If you previously defined Input 1, the lower display contains the value.

  If you have not previously defined it, the lower display contains 5 underscores and a decimal for linear, thermocouple or RTD functions. It contains either blanks or 5 dashes for all other functions. If the display is blank, you can assign a value.
- Key in the value (use the "-" key before a negative value) and press the ENTER key.
- Press the INPUT key again to assign Input 2. The upper display contains a 2 (Input 2).
- Key in the value and press the ENTER key.

To assign Output 1 and Output 2:

- Press the OUTPUT key. The alphanumeric display contains an O (output) and the upper display contains a 1 (Output 1).

  If you previously defined Output 1, the lower display contains the value.

  If you have not defined it, the lower display contains 5 underscores and a decimal for linear, thermocouple or RTD functions. It contains either blanks or 5 dashes for all other functions. If the display is blank, you can assign a value.
- Key in the value (use the "-" key before a negative value) and press the ENTER key.
- Press the OUTPUT key again to assign Output 2. The upper display contains a 2 (Output 2).

  Key in the value and press the ENTER key.

To view input and output values at other channels, press the INCREMENT or DECREMENT key.

4.3.4 Limits

A limit is a five-digit value that specifies a bound against which channel (but not CALC channel) output data is compared. See Section 7 for more information.

Each channel has two independently assignable limits: Limit 1 and Limit 2. Assign the function code and decimal code before assigning limits. If you change the function code or decimal code, limits are nulled. Press the LIMIT TYPE and ENTER keys to restore them.

Limit 1 can be high, low or rate-of-change. Limit 2 can be high or low.

High and low limits are self-explanatory. Assign the high trip point to the high limit and the low trip point to the low limit. If the output data goes out-of-limit, the system takes appropriate action. A rate-of-change limit specifies a bound on the fluctuation in channel output data during the time interval specified by System Timer 16.

Digi 4 Plus automatically places the decimal in a limit in the same position as the decimal code.

To assign Limit 1:

- Press the CHANNEL key and key in a channel address.
- Press the LIMIT key. The leftmost position of the upper display contains a 1 (Limit 1).

  If you previously defined Limit 1, the lower display contains that value; the alphanumeric displays the letter H, L or C (high, low or rate-of-change).

  If you have not defined it, the lower display contains 5 underscores and a decimal. The alphanumeric display contains the letter H.
- Press the LIMIT TYPE key until the alphanumeric display contains the letter representing the limit type.
- Key in a value and press the ENTER key.

To assign Limit 2:

- Press the LIMIT key again. The leftmost position of the upper display contains a 2 (Limit 2).

  If you previously defined Limit 2, the lower display contains that value; the alphanumeric displays the letter H or L (high or low).

  If you have not defined it, the lower display contains 5 underscores and a decimal. The alphanumeric display contains the letter H.
- Press the LIMIT TYPE key until the alphanumeric display contains the letter representing the limit type.
- Key in a value and press the ENTER key.

To view limits at other channels, press the INCREMENT or DECREMENT key.

4.3.5 Limit Operation Codes

A limit operation code (limit op-code) is a six-digit number that controls the action taken when channel (but not CALC channel) output data goes out of limit, returns within limit, goes open circuit or over-range, or returns from open circuit or over-range. See Section 7 for more information.

To assign limit op-codes:

- Press the CHANNEL key and enter the channel address.
- Press the LIMIT and LIMIT OP-CODE keys. The upper display contains the channel address and limit number. The alphanumeric display contains a 1 (Limit Op-Code 1).
- If you previously defined Limit Op-Code 1, the lower display contains the value.

  If you have not defined it, the lower display contains six zeros.
- Key in the value and press the ENTER key.
- Press the LIMIT OP-CODE key again. The alphanumeric display contains a 2 (Limit Op-Code 2).
- Key in the value and press the ENTER key.
- Press the LIMIT OP-CODE key a third time. The alphanumeric display contains a 3 (Limit Op-Code 3).
- Key in the value and press the ENTER key.

To view op-codes at other channels, press the INCREMENT or DECREMENT key.

4.3.6 Engineering Units

You can assign a single alphabetic character to each channel (and CALC channel) that describes engineering units. Digi 4 Plus automatically enters units for voltage inputs, RTD's and thermocouples.

To assign units:

- Press the CHANNEL key and enter the channel address.
- Press the UNITS key. If you have not previously assigned units, the alphanumeric display is blank.
- Press the ALPHA SHIFT key.
- Key in the letter that identifies the units, and press the ENTER key.

To view the units at other channels, press the INCREMENT or DECREMENT key.

4.3.7 Labels

A channel label is an 8-character textual description of data at a channel (but not a CALC channel). Assign each label to a text address (101-816) that corresponds to the channel address (101-816). See Section 8 for more information.

To assign a label:

- o Press the TEXT key. The upper display contains the last text address accessed. The lower and the alphanumeric displays are blank.
- o Key in the text address and press the ENTER key. The alphanumeric display contains the first character in the message or a blank if no text has been entered. The lower display contains 01. This indicates the first character in the label.
- o Key in the label and press the ENTER key. If it contains alphabetic characters, you must use the alpha-shift mode. The alphanumeric display shows each character as you enter it and the number in the lower display increments by 1.

4.4 OUTPUTTING A CONSTANT

There are several ways to set up a channel (or CALC channel) to output a constant. However, we believe this is the easiest method:

- o Assign Function Code 114 (transfer) to the channel or CALC channel.
- o Enter the constant value at Input 1 with the decimal in the desired location.
- o Redefine the decimal code to match the Input 1 constant.

4.5 COPYING ASSIGNMENTS

You can copy values from one channel address to another in order to save time.

To copy an assigned value:

- o Press the CHANNEL key and enter the address that contains the value.
- o Press the key for the parameter you want to copy and press the ENTER key.
- o Press the ADVANCE key until the upper display contains the address that is to receive the value.
- o Press the ENTER key.

SECTION 5 - FUNCTIONS

5.1 GENERAL INFORMATION 5-1

5.2 SKIP FUNCTION (000) 5-2

5.3 SYSTEM INPUT FUNCTIONS (001-050) 5-3
- 5.3.1 Voltage Functions (001-005) 5-9
- 5.3.2 Linear Input Functions (006-017) 5-10
- 5.3.3 Thermocouple Functions (018-038) 5-20
- 5.3.4 RTD Functions (039-046) 5-22
- 5.3.5 Multi-Segment Input Functions (047-050) 5-23

5.4 LINEAR TRANSFER FUNCTIONS (051-053) 5-25

5.5 MULTI-SEGMENT TRANSFER FUNCTION (054) 5-28

5.6 DATA ACCUMULATION FUNCTIONS (055-058). 5-29

5.7 METER FUNCTION (059) 5-34

5.8 COUNTER FUNCTION (060) 5-36

5.9 INTERVAL FUNCTIONS (061-064) 5-37

5.10 ELAPSED TIMER FUNCTIONS (065-066). 5-40

5.11 HISTORICAL BUFFER FUNCTIONS (067-074) 5-42

5.12 GROUP FUNCTIONS (075-081) 5-44

5.13 PAIR FUNCTIONS (082-083) 5-46

5.14 MATH FUNCTIONS (084-098) 5-47

5.15 POLYNOMIAL TRANSFER FUNCTION (099) 5-48

5.16 OPTIONAL DATA STORAGE FUNCTION (100) 5-50

5.17 BOOLEAN FUNCTIONS (101-107). 5-51

5.18 FLIP FLOP FUNCTIONS (108-111). 5-54

5.19 DATA COMPARE FUNCTIONS (112-113). 5-57

5.20 DATA TRANSFER FUNCTIONS (114-115) 5-58

5.21 DATA SELECT FUNCTIONS (116-120) 5-61

5.22 INTEGER ENCODER FUNCTIONS (121-122) 5-63

5.23 CONTROL COUNTER FUNCTION (123) 5-65

5.24 CONTROL TIMER FUNCTIONS (124-127) 5-66

5.25 INDIRECT TRANSFER FUNCTION (128) 5-68

5.26 LOGICAL TRANSFER/LOAD DATA VALUE FUNCTION (129) 5-71

5.27 APPLICATION FIRMWARE FUNCTIONS (130-133) 5-72
5.27.1 Relative Humidity Function (130) 5-74
5.27.2 Cylindrical Tank Volume Function (131) 5-74
5.27.3 Spherical Tank Volume Function (132) 5-75
5.27.4 Lethality Rate Function (133) 5-76

5.28 CONTROL FIRMWARE FUNCTIONS (140-150) 5-78
5.28.1 Proportional Control/External Reset Functions (140-141) 5-79
5.28.2 Standard PID Functions (142-143) 5-80
5.28.3 Batch Preload PID Functions (144-145) 5-81
5.28.4 Cascade PID Functions (146-147) 5-82
5.28.5 Auto Manual Track and Hold Function (148) 5-83
5.28.6 Auto Manual Track and Hold Function (149) 5-84
5.28.7 Sequencer Function (150) 5-85

5.29 APPLICATION FIRMWARE FUNCTIONS (160-195) 5-86
5.29.1 Weighted Mixture Function (160) 5-87
5.29.2 Specific Volume of a Perfect Gas Function (161) 5-89
5.28.3 Specific Volume of Natural Gas Function (162) 5-92
5.29.4 Specific Volume of Steam Functions (163 and 165) 5-94
5.29.5 Enthalpy of Steam Functions (164 and 166) 5-95
5.29.6 Specific Volume/Higher Value of Natural Gas Mixtures Function (167) . . 5-96
5.29.7 Orifice Flow Functions (170-174) 5-99
5.29.8 Compressor Efficiency Function (175) 5-102
5.29.9 Orifice Flow/Upstream Pressure Tap Function (176) 5-104
5.29.10 Flow Nozzle Function (177) 5-106
5.29.11 Venturi Meter Function (178) 5-108
5.29.12 Saturation Pressure of Steam Functions (180-181). 5-110
5.29.13 Saturation Temperature of Steam Functions (182-183). 5-111
5.29.14 Entropy of Steam Functions (184-185) 5-112
5.29.15 Specific Volume of Water Functions (186-187) 5-113
5.29.16 Enthalpy of Water Functions (188-189) 5-114
5.29.17 Entropy of Water Functions (190-191) 5-115
5.29.18 Isentropic Efficiency of Turbine Stage Functions (192-193). 5-116
5.29.19 Exhaust Quality/Enthalpy of Turbine Stage Functions (194-195) 5-117

5.30 ZERO OFFSET FUNCTION (199) 5-118

5.31 AUTOMATIC DATA STORAGE FUNCTIONS (201-209 and 211) 5-120

5.1 GENERAL INFORMATION

A function is a computational routine. You must assign a function code to a channel address (101-816) or a CALC channel address (001-099) before Digi 4 Plus can accept, process or monitor data. A function code specifies the exact operation Digi 4 Plus performs on the input data and determines additional parameters. These parameters include:

- o Resolution of output data (decimal code)
- o Source data
- o Input and output constants
- o Limits and limit op-codes
- o Units

Channels accept all function codes. CALC channels do not accept the following:

- o System input functions (001-050)
- o Accumulation functions that output a single line of data (056-058)
- o Meter function (059)
- o Boolean functions (101-107)
- o Flip-flop functions (108-111)
- o Data compare functions (112-113)
- o Control counter functions (123)
- o Track-and/or-hold functions (148-149)
- o Sequencer function (150)

You cannot specify limits or limit op-codes at CALC channels or include their data in reports.

If a function code uses multiple channels, they must all be the same type (channels or CALC channels).

Assign function codes only in the Program mode. If you change a function code, all other parameters are nulled and you must re-enter new ones. If you do not assign a value to a required parameter, an over-range occurs.

The following sections describe each function code. The Digi 4 Plus Quick Reference also contains function overview charts.

5.2 SKIP FUNCTION (000)

When the system is initialized, it assigns Function Code 000 (skip function) to Channel Addresses 201-816 and CALC Channel Addresses 01-99. The skip function indicates no data is processed at that address.

If you assign the skip function to a channel previously assigned a non-zero function code, the channel is disabled. Any parameters assigned that channel are nulled.

The skip function also affects data reports.

- If you do not include individual channel addresses in a report, the system leaves a blank space for each channel assigned the skip function.
- If you include individual channel addresses in a report, the system does not leave space for channels assigned the skip function.

5.3 SYSTEM INPUT FUNCTIONS (001-050)

System input is data that enters Digi 4 Plus from a sensor directly connected to a Digi 4 Plus input scanner (analog or RTD) or from an external scanner such as a Kaye DS-8, FS-8 or another Digi 4 Plus. Voltage, thermocouple, RTD, linear input and multi-segment input functions are system input functions.

CALC channels do not accept Function Codes 001-050.

System input functions display a direct voltage measurement, convert a voltage reading to a temperature or convert a voltage reading to engineering units. Filtering and automatic calibration (Autocal) can be applied to most system input functions (Figure 5-1).

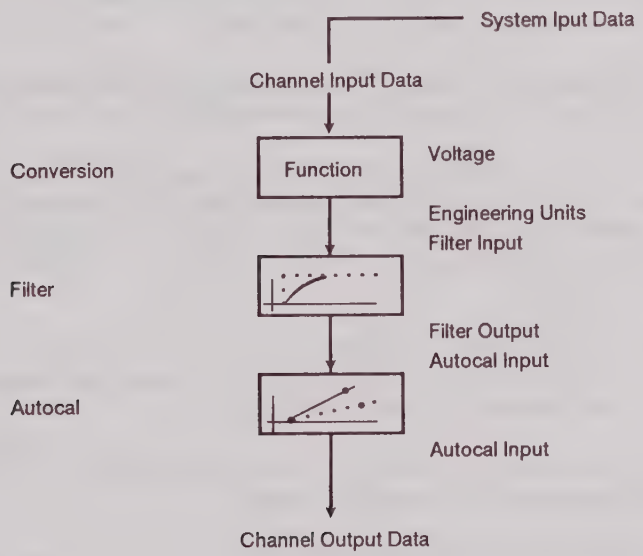


Figure 5-1. System Input Functions

Filtering

Digi 4 Plus has a sampled approximation of an R-C low pass filter. Filtering minimizes response to spurious noise on input data. Digi 4 Plus can filter all system input functions (except multi-segment input functions) with the following algorithm:

$$y_n = y_{n-1} + \frac{(x_n - y_{n-1})}{1 + (\text{Filtertime}/\text{Scantime})}$$

Where:

y_n = New filter output
x_n = Current filter input
y_{n-1} = Last filter output
Filtertime = Filter time constant in seconds
Scantime = Analog scan time in seconds (sample interval) displayed at Channel 911

Notice that the new filter output (y_n) is formed from the current input (x_n) and the previous filter output (y_{n-1}). The response time to changes in the value of the current filter input is directly related to the filter time constant.

Figure 5-2 on the following page shows how filtering affects output data. In all three examples input data is the same, but the filter time constants are different. Notice how a change in the filter time alters the temperature output: the greater the filter time constant, the less weight ascribed to the current filter input.

Example A has no filtering. Output data reflects input data exactly. Notice that the output data responds immediately to a 40 degree change in temperature.

Example B has a 10 second filter time. Output data does not respond as quickly to a change in temperature. At the 5 second sample time (t=5), the channel output reflects only a percentage (approximately 28%) of the input change.

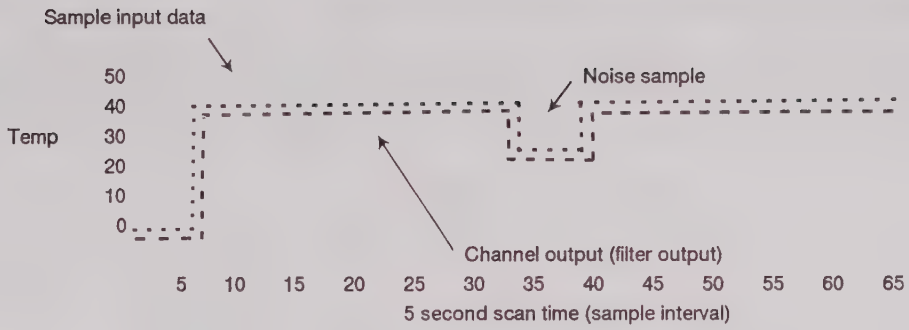
Example C has a 60 second filter time. At the 5 second sample time (t=5), the channel output reflects an even smaller percentage (approximately 6%) of the input change.

Filter time can be any value between 0 and 65535 seconds. The value is process dependent. Specify a filter time that allows process noise to be smoothed out, but does not unduly delay response to a process change. For example, a filter time of 60 seconds may be suitable for a sensor measuring a tank volume, but unacceptable for one measuring flow out of the tank.

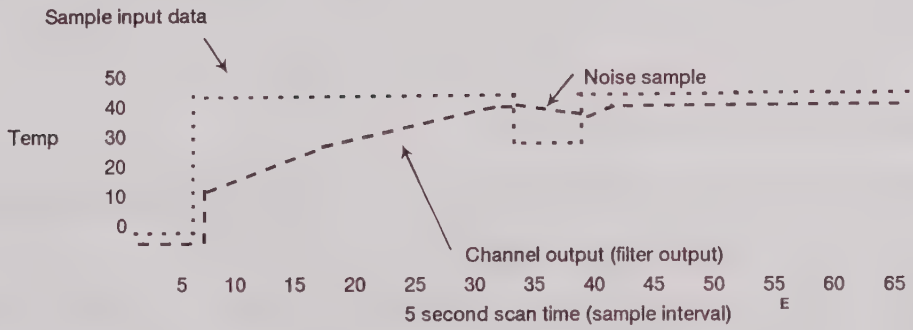
Source 2 of the channel assigned the system input function specifies the address of the filter time constant. Assign a user-defined constant (the number of seconds in the filter time) to a channel. See Section 4.4 for more information.

If Source 2 is 000, filtering is not applied. Without filtering, filter output always equals filter input; there is no memory of previous filter outputs.

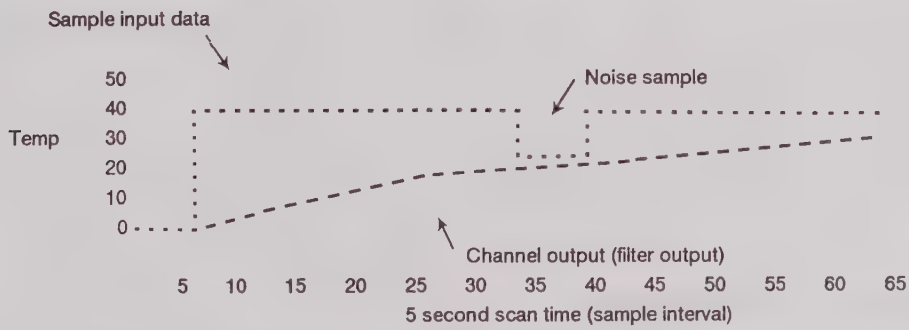
Digi 4 Plus can also apply filtering to Function Codes 051-053 (linear transfer) and to Function Code 064 (interval rate-of-change).



Example A. No Filtering



Example B. 10 Second Filter Time



Example C. 60 Second Filter Time

Figure 5-2. Effects of Filtering on Output Data

Autocal

Automatic calibration (Autocal) allows Digi 4 Plus to calibrate input from any sensor. It requires a stable calibration source and an independent, traceable standard. The output of the conversion and filtering stages are calibrated (Figure 5-1).

Digi 4 Plus can apply Autocal to all system input functions (except voltage functions), to linear transfer functions and to the multi-segment transfer function.

Autocal uses ideal measurement to correct a less than ideal sensor and/or system measurement. It is most useful for highest accuracy measurements.

Define two known calibration points (X_1,Y_1 and X_2,Y_2).

The values are assigned to Input 1, Output 1 and Input 2, Output 2 and usually reflect the value of the calibration sources (Figure 5-3). Initially you define the values on a one-to-one basis. (Assign the Input 1 value to Output 1 and the Input 2 value to Output 2.)

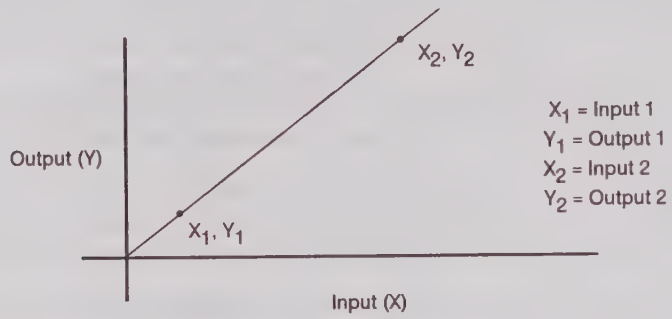


Figure 5-3. Assigning Calibration Points

Autocal can be applied to either the two known calibration points Input 1 and Input 2) or to a single known calibration point (Input 1 or Input 2). The defined output values do not change; the corrections are applied only to the input values.

Two Point Calibration. When Autocal is applied to both Input 1 and Input 2, the slope and the X and Y intercepts change (Figure 5-4).

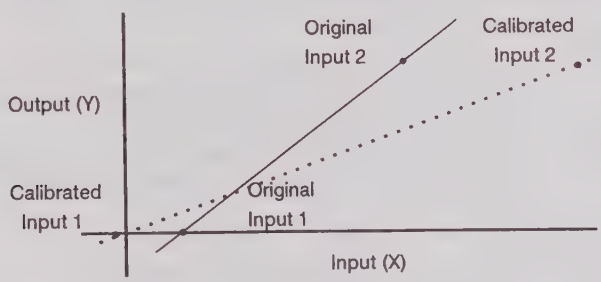


Figure 5-4. Two Point Calibration

Single Point Calibration. Autocal is usually applied to Input 1 to obtain zero corrections. When the value of Input 1 changes, the slope of the curve changes (Figure 5-5).

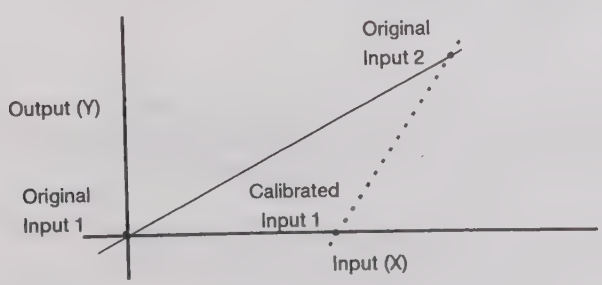


Figure 5-5. Single Point Calibration

In order to maintain the original slope, calculate the difference between the original Input 1 and the calibrated Input 1 and add this value to Input 2. The difference is called the offset. A recalculated Input 2 results when the offset value is added to the original Input 2 value (Figure 5-6).

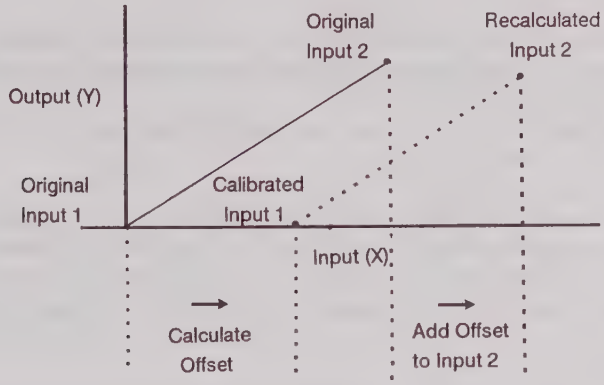


Figure 5-6. Calculating the Offset

Some applications may require single point calibration of Input 2. Digi 4 Plus can apply Autocal to Input 2 to correct span errors or when Input 1 cannot be conveniently calibrated. To calibrate Input 2, follow the procedure for Input 1. To maintain the original slope, calculate the difference between the calibrated Input 2 and the original Input 2 and add this value to Input 1.

As we said before, Autocal requires an accurate calibration source and an independent measuring standard to verify that source. You must define two known calibration points (X_1,Y_1 and X_2,Y_2) at the channel measuring the output of the sensor. Assign these values to Input 1, Output 1, Input 2 and Output 2. Initially, you define these values on a one-to-one basis. (Assign the Input 1 value to Output 1 and the Input 2 value to Output 2.) For example, if the values of the two calibration sources are 0°C and 121.1°C, assign the following values:

Input 1 = 0.0	Output 1 = 0.0
Input 2 = 121.1	Output 2 = 121.1

To calibrate the first point:

- Place the sensor to be calibrated and the measurement standard in the first calibration source.
- Press the CHANNEL key and enter the address of the channel measuring the sensor. If the value of the calibration source does not match the measuring standard, adjust the value assigned to Output 1. For example, if the value of the calibration source should be 0.0 and the measuring standard indicates the actual value is 0.2, assign 0.2 to Output 1.
- See if Input 1 requires calibration. Press the INPUT and ALPHA SHIFT keys to access the current data value in the lower display. If you implemented filtering, the value has been filtered and should match the first calibration point. For example, if the value of the first calibration source is 0.2, the lower display should contain 0.2. The display does not automatically change in real time. Press the ALPHA SHIFT key repeatedly to see if the current data value is changing.

If the value in the display does not match the calibration source, press the ENTER key so the data in the display is the new value of Input 1. For example, if the lower display contains 0.5, press the ENTER key to make 0.5 the new value.

To calibrate the second point:

- o Place the sensor to be calibrated and the measurement standard in the second calibration source. Follow the procedure above to calibrate Output 2 and Input 2.

Notice that the user-defined output values are not automatically updated. Autocal only adjusts user-defined input values.

Example: Perform a 2-point calibration on a type T thermocouple at Channel Address 115. A Kaye Ice Point Reference (Model K140-4) and a Kaye High Temperature Reference (Model HTR-150) are the calibration sources. The two known calibration points are 0°C and 121.1°C. Assign 0.0 to Input 1 and Output 1, and 121.1 to Input 2 and Output 2.

To calibrate the first point:

- o Place the thermocouple and a measuring standard in the Ice Point Reference. The measuring standard indicates the calibration source is 0.0°C, so you do not have to adjust the value of Output 1.
- o Access Channel 115. If the display contains a value other than 0.0, you must calibrate the thermocouple. Press the ALPHA SHIFT key repeatedly to make sure this value is stable. For this example, assume the display contains 0.5. Since this value does not match the value of the calibration source, you must calibrate Input 1.
- o Press the INPUT, ALPHA SHIFT and ENTER keys to make 0.5 the new value of Input 1.

To calibrate the second point:

- o Place the thermocouple and a measuring standard in the High Temperature Reference. The measuring standard indicates the calibration source is 121.3°C, so you must adjust the value of Output 2.
- o Press the OUTPUT key twice and assign 121.3 to Output 2.
- o Press the INPUT key twice and the ALPHA SHIFT key once. If the display contains a value other than 121.3, calibrate the thermocouple. Press the ALPHA SHIFT key repeatedly to make sure this value is stable. For this example, assume the display contains 120.4. Since this value does not match the value of the calibration source, you must calibrate Input 2.
- o Press the ALPHA SHIFT and ENTER keys to make 120.4 the new value of Input 2.

Open Circuit Test

There is an open circuit test for voltage, linear input, thermocouple, RTD and multi-segment input functions using the +/-30mV, +/-60mV or +/-600mV range. If the sensor wire is open, the lower display goes blank, the open circuit indicator light goes on and the word "open" appears in reports. There is no open circuit test for the +/-6V and +/-12V ranges. If the sensor wire is open on these ranges, a drifting voltage results, which may cause inaccurate output data. An over-range occurs when the input voltage exceeds the voltage specified.

5.3.1 Voltage Functions (001-005)

Functions 001-005 display direct voltage measurement or perform digital filtering on a transducer input. With digital filtering, you must assign a linear transfer function to a second channel if the measured voltage is scaled to units of the measured property.

Code	Range	Units	
001	+/-60.000 mV	M	(Open circuit test)
002	+/-600.00 mV	M	(Open circuit test)
003	+/-6.0000 V	V	
004	+/-12.000 V	V	
005	+/-30 mV calibration		(Open circuit test)

Parameters

Source 1 is not assigned a value. Source 2 is the address of the filter time constant. See Section 4.4 for more information.

Input 1, Input 2, Output 1 and Output 2 are not used.

You cannot assign units or redefine the decimal code. Digi 4 Plus automatically assigns engineering units (M for millivolts and V for volts). For Function Codes 001-004, Digi 4 Plus places the decimal in the same position as the input voltage.

Operation

Determine the maximum voltage value expected from the system input data and assign the appropriate function code. For greatest output resolution, select the function code with the smallest input range that supports the maximum voltage value.

Example: Your maximum expected input voltage is 2V. Assign Function Code 003 (+/-6.0000V) for best output resolution.

For measurements above 12V, place a voltage divider (VD-100) across the appropriate Digi 4 Plus terminal bank to reduce input voltage by a factor of 100. When selecting the voltage range, use the reduced input voltage value. For example, if a sensor has a 0 to 20V output, the VD-100 reduces the voltage to 0 to 0.2 V (0 to 200mV). Assign Function Code 002 for best output resolution.

Digi 4 Plus cannot measure transducers with a direct current output unless you place a precision shunt resistor across the input terminals. If a 4 to 20mA signal is measured with a precision 62.5 ohm shunt resistor, the input voltage is between .25 to 1.25 volts (250 to 1250mV). Assign Function Code 003 for best output resolution.

Function Code 005 calibrates the system's 30mV range and the external compensation of Type B, R, S and T thermocouples. It doubles the input and shifts the decimal one position to the left. For example, 30mv is displayed as 6.0000.

5.3.2 Linear Input Functions (006-017)

Functions 006-017 take the voltage from a system input and convert it into engineering units (such as gallons per hour or pounds per square inch). The conversion has a straight-line relationship; two points must be known. Filtering and Autocal can be applied.

Code	Voltage Range	Output Constraint Type	
006	+/-60.000 mV	Un-bounded	(Open circuit test)
007	+/-600.00 mV	Un-bounded	(Open circuit test)
008	+/-6.0000 V	Un-bounded	
009	+/-12.000 V	Un-bounded	
010	+/-60.000 mV	Bounded	(Open circuit test)
011	+/-600.00 mV	Bounded	(Open circuit test)
012	+/-6.0000 V	Bounded	
013	+/-12.000 V	Bounded	
014	+/-60.000 mV	Clamped	(Open circuit test)
015	+/-600.00 mV	Clamped	(Open circuit test)
016	+/-6.0000 V	Clamped	
017	+/-12.000 V	Clamped	

Parameters

Source 1 is not assigned a value. Source 2 is the address of the filter time constant.

Input 1, Output 1 and Input 2, Output 2 must be assigned values. They specify the two known input/output points.

The decimal defaults to the rightmost position unless redefined. Linear input functions output extended precision data and displayed and logical data. You can define units.

Operation

System input data (which represents a voltage reading) must be directed to a channel assigned a linear input function. To convert this reading into the desired output, define two known input/output points, (X_1,Y_1) and (X_2,Y_2) to set up a direct correspondence between channel input and output data.

Input 1 = X_1 Output 1 = Y_1
Input 2 = X_2 Output 2 = Y_2

After you define (X_1,Y_1) and (X_2,Y_2), the system calculates the slope and the intercept of the function (Figure 5-7).

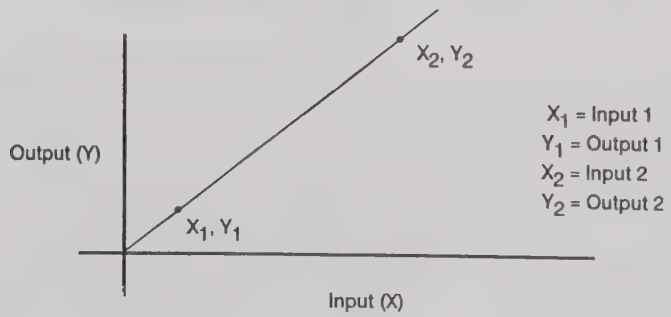


Figure 5-7. Calculating the Slope of a Linear Input Function

The system automatically places the decimal point for Input 1 and Input 2 in the same location as the input voltage range of the function code. You assign the Output 1 decimal point location and Digi 4 Plus sets the Output 2 decimal point in the same position.

The decimal code defines the resolution for the displayed output data. The resolution determines the maximum value of the displayed output data. If the displayed output data exceeds the display value, an over-range occurs. If displayed data is over-range, extended precision output may be still valid and can be used by a channel that accepts extended precision data.

To select a linear input function:

- Determine the maximum voltage expected from your input.

  For voltage measurements above 12V, place a voltage divider (VD-100) across the Digi 4 Plus terminal bank. The VD-100 reduces the input voltage by a factor of 100. To determine the maximum voltage, use the reduced input voltage value. For example, if a sensor has a 0 to 20 volt output, the VD-100 reduces the voltage to 0 to 0.2 volts (0 to 200mV). 0.2 volts (200mV) is the maximum expected voltage.

  Digi 4 Plus cannot measure transducers with a direct current output unless you place a precision shunt resistor across the input terminals. When determining the maximum voltage, use the maximum voltage produced across the resistor. For example, if a 4 to 20mA signal is measured with a precision 62.5 ohm shunt resistor across the input terminals, the input voltage is between .25 to 1.25 volts (250 to 1250mV). The maximum expected voltage is 1.25 volts (1250mV).

  Treat external scanner inputs other than voltage, such as system input data from a DS-8 and FS-8, as a 60 millivolt reading. See the documentation supplied with your scanner for more information.

- Select the input range that supports the maximum voltage expected.

  Output resolution decreases as the input voltage increases. For the best accuracy, select the smallest input range that supports the maximum expected input. For example, if your maximum expected input voltage is 55mV, the 60mV range has the greatest input resolution. Greater input resolution results in better accuracy in the output data.

- Choose the output constraint type: bounded, un-bounded or clamped. (These terms are explained below.)

- Assign the function code that includes the input voltage range and the output constraint type.

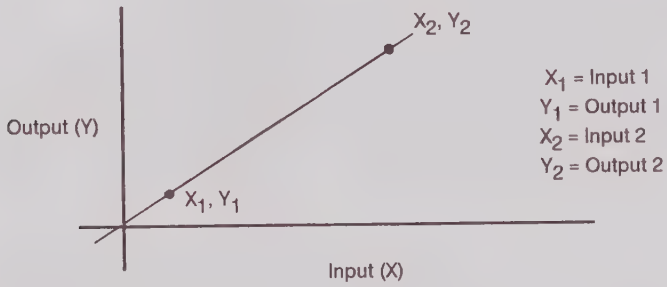
Un-bounded, Bounded and Clamped Linear Input Functions

Unbounded Linear Input Functions (006-009) follow the linear relationship until an over-range occurs. You can specify any two points (input voltages and corresponding outputs) within the input voltage range of the function. The two points are defined by (X_1,Y_1) and (X_2,Y_2). You cannot assign X_1 and X_2 the same value. The output data follows a linear relationship over the entire input voltage range of the function.

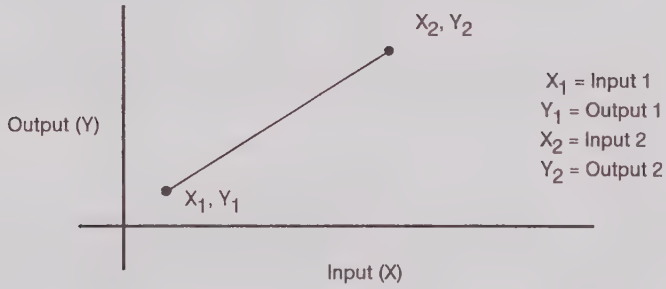
Bounded Linear Input Functions (010-013) follows the linear relationship until the input voltage is outside the range of voltage values defined by Input 1 and Input 2. An over-range occurs when the input voltage is less than Input 1 or greater than Input 2. The voltage value specified by Input 1 must be less than the voltage value specified by

Input 2. Endpoint values (input voltages and corresponding outputs), must define the two known points (X_1,Y_1) and (X_2,Y_2).

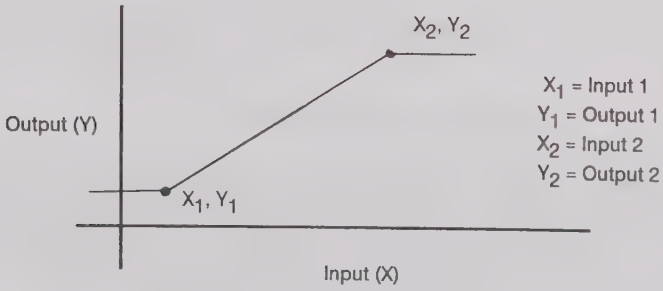
Clamped Linear Input Functions (014-017) follow a linear relationship until the input voltage is outside the range of voltage values defined by Input 1 and Input 2. The voltage value specified by Input 1 must be less than the voltage value specified by Input 2. The end points values (input voltages and corresponding outputs) must define the two known points (X_1,Y_1) and (X_2,Y_2). If the input voltage is not within X_1 and Y_2, the output data equals Output 1 when the input voltage is less than Input 1 and the output data equals Output 2 when the input voltage is greater than Input 2. An over-range occurs when the input voltage range of the function is exceeded.



Un-Bounded Linear Input Functions



Bounded Linear Input Functions



Clamped Linear Input Functions

Figure 5-8. Linear Input Functions

Use an un-bounded linear input function when channel output data follows the linear relationship for the entire voltage range.

Use a bounded linear input function when channel output data follows a linear relationship within the boundaries of two defined endpoints.

Use a clamped linear input function to limit channel output to a meaningful range. Channel output data follows a linear relationship if the input data is within the boundaries of the two defined endpoints. If input data goes outside these boundaries, output data is clamped to the Y value of the corresponding endpoint:

- The output data of a channel assigned a clamped linear input function is set to a minimum output value (Y_1) when input voltage from a transducer is below a minimum value (X_1). For current inputs, X_1 is the voltage across the precision shunt resistor induced at the minimum current value.
- The output data of a channel assigned a clamped linear input function is set to a maximum output value (Y_2) when the input voltage from a transducer is above a maximum value (X_2). For current inputs, X_2 is the voltage across the precision shunt resistor induced at the maximum current value.

Displayed and extended precision output data go open when:

- System input data is not directed to the channel
- Digi 4 Plus has not received a system input reading from an external scanner within 20 seconds

Functions 006, 007, 010, 011, 014 and 015 also go open circuit if the sensor wire connected to the Digi 4 Plus terminal bank is open.

There is no open circuit test for system input functions using the +/-6.0V or +/-12V range. If the sensor wire is open for channels using these input voltage ranges the following may occur:

- For Functions 008 and 009, drifting input voltage causes inaccurate output data.
- For Functions 012 and 013, drifting input voltage causes inaccurate output data or an over-range. The latter results if the drifting voltage value is outside the range of voltage values specified by the end points (Inputs 1 and 2).
- For Functions 016 and 017, drifting input voltage causes inaccurate output data or the output data is set to the Output 1 or Output 2 values. The latter results if the drifting voltage is outside the range of voltage values specified by the end points (Inputs 1 and 2).

For all linear input functions, the displayed and extended precision output data goes over-range if:

- One input/output point is not defined
- Input 1 is assigned a value greater than Input 2
- The display capacity is exceeded (+/-65535, +/-6553.5, +/-655.35, +/- 65.535, or +/-6.5535)

Extended precision output data is still valid data and can be used by a channel that accepts extended precision inputs.

Un-bounded and clamped linear input functions also go over-range if the input voltage is outside the voltage range of the assigned function. Bounded linear input functions go over-range if the input voltage is outside the voltage range specified by the end points (Input 1 and Input 2).

Figures 5-9 and 5-10 on the following page show conditions that cause an over-range. The figures are divided into 5 regions to distinguish input over-range, display over-range and valid data.

Figure 5-9. Un-Bounded and Clamped Linear Input Functions

Regions 1 and 3. An over-range (both displayed and extended precision data) occurs if the input voltage exceeds the boundaries specified by the function code.

Regions 2 and 4. An over-range (displayed data only) occurs if the channel output data exceeds the display capacity (+/-65535, +/-6553.5, +/-655.35, +/-65.535, or +/-6.5535). Extended precision data is still valid, even though it is not visible at the channel. A clamped linear function does not go into a display over-range because the output data is clamped to the Y_1 value when the input data is less than X_1 and to the Y_2 value when the input is greater than X_2. (Dots indicate the clamped output.)

Region 5. A valid data area has input data within the voltage range of the assigned function code and output data that does not exceed the display capacity.

Figure 5-10. Bounded Linear Input Functions

Regions 1 and 3. An over-range (both displayed and extended precision data) occurs if the input voltage exceeds the boundaries specified by the endpoints, X_1 and X_2.

Regions 2 and 4. An over-range (displayed data) occurs if the channel output data exceeds the display capacity (+/-65535, +/-6553.5, +/-655.35, +/- 65.535, or +/-6.5535). Extended precision data is still valid, even though it is not visible.

Region 5. A valid data area has input data within the voltage range defined by X_1 and X_2 and output data that does not exceed the display capacity.

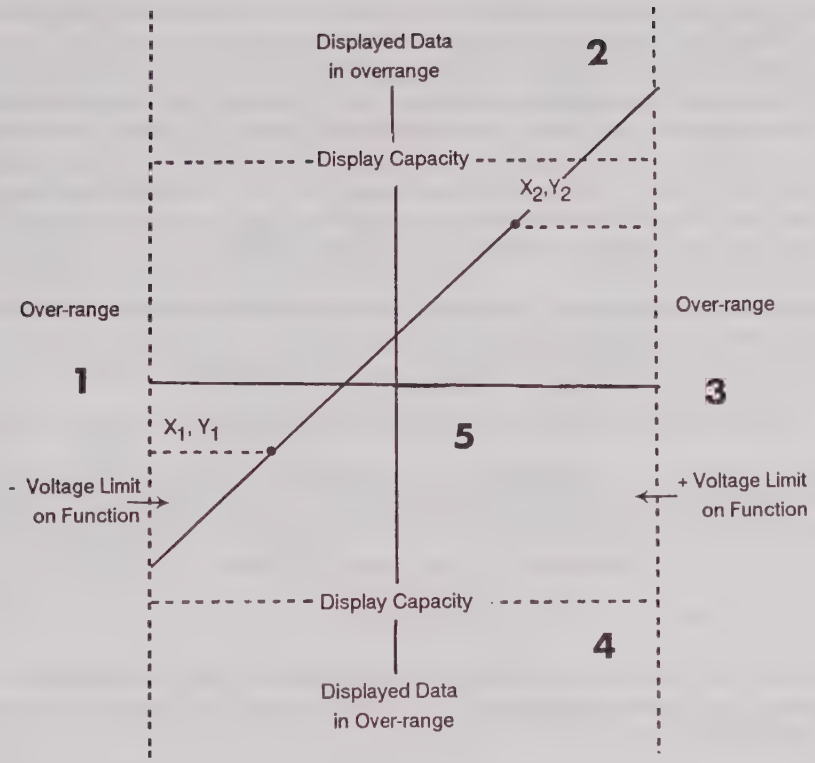


Figure 5-9. Unbounded and Clamped Linear Input Functions

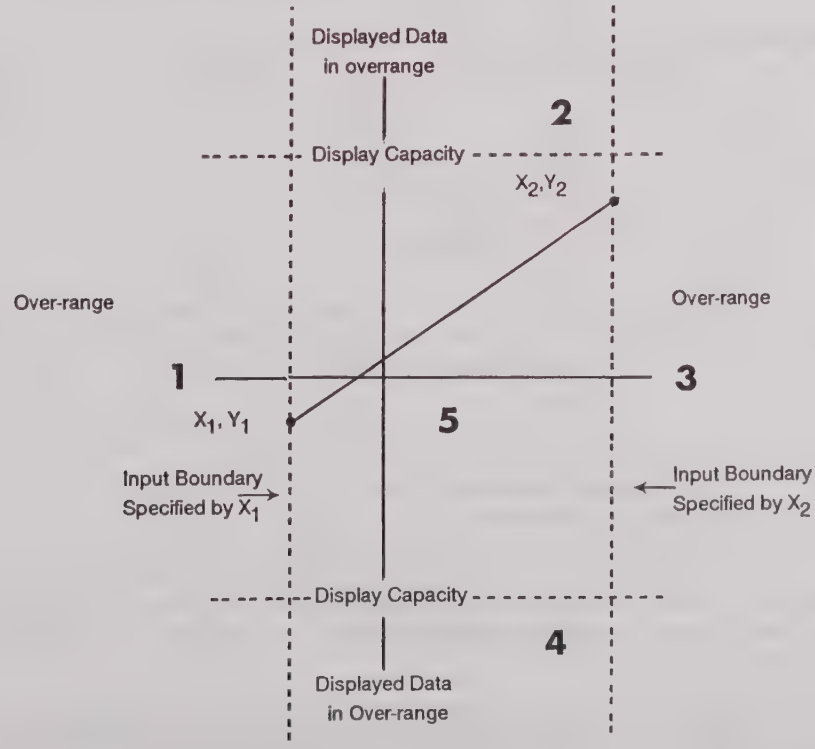


Figure 5-10. Bounded Linear Input Functions

Example 1 (un-bounded): A boiler operator wants to connect a linear pressure transducer to Digi 4 Plus and receive a displayed pressure reading with a 0.1 PSI resolution. The pressure to voltage characteristics of the pressure transducer are 10.75mV per 1.35 PSI and 0 millivolts at a zero pressure measurement. The maximum expected boiler pressure is 30 PSI. The output voltage of the transducer is approximately 240mV at 30 PSI.

30 PSI (240mV) is the maximum expected input voltage and determines the input voltage range. He selects a 600.00mV unbounded linear function for best resolution (.01mV) and to display pressure readings outside the two defined points.

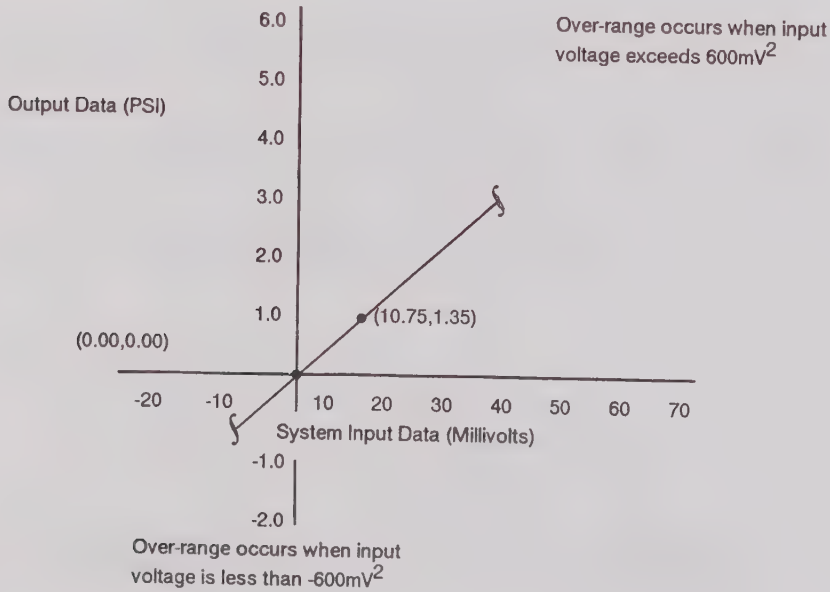
Using the voltage to pressure characteristics of the pressure transducer and the pressure measurement at zero, he assigns the following values:

Input 1 = X_1 = 000.00	Output 1 = Y_1 = 000.00[1]
Input 2 = X_2 = 010.75	Output 2 = Y_2 = 001.35

The output decimal point defaults to the rightmost position, unless redefined. In this example, he redefines the decimal code as 0000.0 in order to match the resolution of the displayed pressure reading. Extended precision output may have greater resolution and is available for channels that accept extended precision inputs.

He assigns the letter P (PSI) to the units parameter.

Digi 4 Plus uses the two points (0.00,0.00) and (10.75,1.35) to compute the slope and intercept and to convert the system input data from millivolts to a pressure reading with a displayed resolution of 0.1 PSI.



---

1. Since Digi 4 Plus automatically assigns Output 1 and Output 2 the same decimal location, the Output 1 decimal location (000.00) was chosen to support the Output 2 value, (1.35).

2. An input voltage of +/-600.00mV equals a pressure reading of +/-81.6 PSI. The input voltage will exceed the +/-600.00mV range before the display capacity is exceeded. An open sensor wire will cause an open circuit on the +/-600.00mV range.

Example 2 (bounded): A plant engineer wants to monitor the flow rate of molasses. He knows that the flow rate can range from 30 to 180 gallons per hour (GPH) during production. A flow transducer that has a linear voltage output, 10mV to 55mV for flow rates between 30 to 200 GPH, monitors the flow. When production is stopped, the flow rate drops below 30 GPH and the output of the transducer will be less than 10mV. The plant engineer wants to display the flow rates with a resolution of 0.1 GPH and totalize the flow only during production.

He uses the voltage output at 200 GPH (55mV) as the maximum expected input voltage to determine the input voltage range of the linear function. He selects the 60.000mV range because it allows the best input resolution (.001mV) in converting the voltage to the displayed flow rate. He selects a bounded output in order to display an over-load below a 30 GPH flow rate and assigns Function Code 010 (60.000mV bounded linear input).

Another channel assigned an accumulation function (055-058) can totalize the flow.

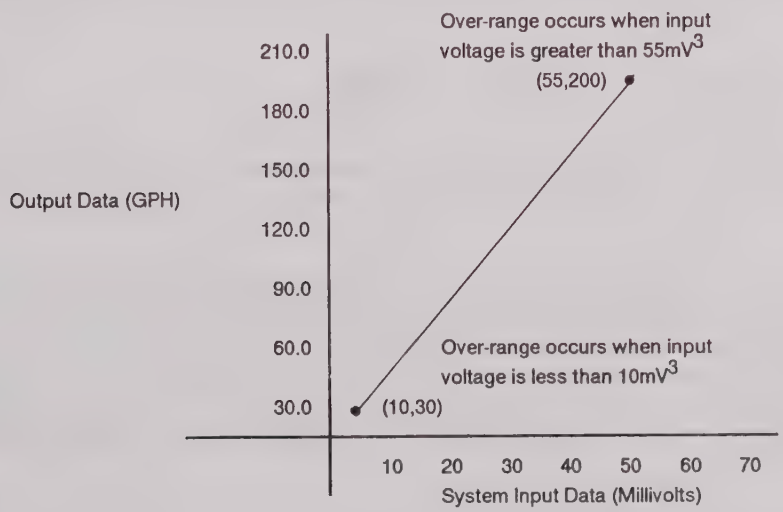
The output voltages (10mV and 55mV) and the corresponding flow rates of the flow transducer (30 and 200 GPH) are used to define the endpoints, (X_1,Y_1) and (X_2,Y_2). The following values are assigned:

Input 1 = X_1 = 10.000	Output 1 = Y_1 = 00030
Input 2 = X_2 = 55.000	Output 2 = Y_2 = 00200

The output decimal defaults to the rightmost position unless redefined. In this example, the decimal code is redefined as 0000.0 in order to match the resolution of the displayed flow rate. Extended precision output may have greater resolution and is available for channels that accept extended precision inputs.

He assigns the letter G (GPH) to the units parameter.

Digi 4 Plus uses the two points, (10,30) and (55,200) to compute the slope, and to convert the input data from millivolts to gallons per hour with a displayed resolution of 0.1 GPH. The figure below shows the output data.



---

3. The endpoints have a displayed flow rate reading of 30.0 and 200.0. The input voltage will exceed the endpoint values (10mV and 55mV) before the display capacity is exceeded. An open sensor wire causes an open circuit on the 60mV range.

Example 3 (clamped): A plant engineer wants to monitor electrical use with a watt meter that has a linear 4 to 20mA current output (0 to 3000 kilowatts). She wants to display the rate with whole number resolution in KW and also wants to display a 0 KWH rate when the current output drops below 4mA.

Digi 4 Plus does not measure direct current outputs. A transducer with a direct-current output needs a precision shunt resistor across the system's input terminals to produce a a measurable voltage. For this example, assume that a 62.5 ohm precision resistor is attached.

Before selecting the input voltage range, she must convert the direct current output (4 to 20mA) to a voltage measurement using the formula:

V (volts) = A (current in amperes) X R (resistance in ohms)

Convert 4mA (.004A) to voltage:

V = .004A (4mA) X 62.5ohms
= 0.25V

Convert 20mA (.020A) to voltage:

V = .020A (20mA) X 62.5ohms
= 1.25V

A transducer with a 4 to 20mA current output across a 62.5 ohm resistor produces a 0.25V to 1.25V input to her system.

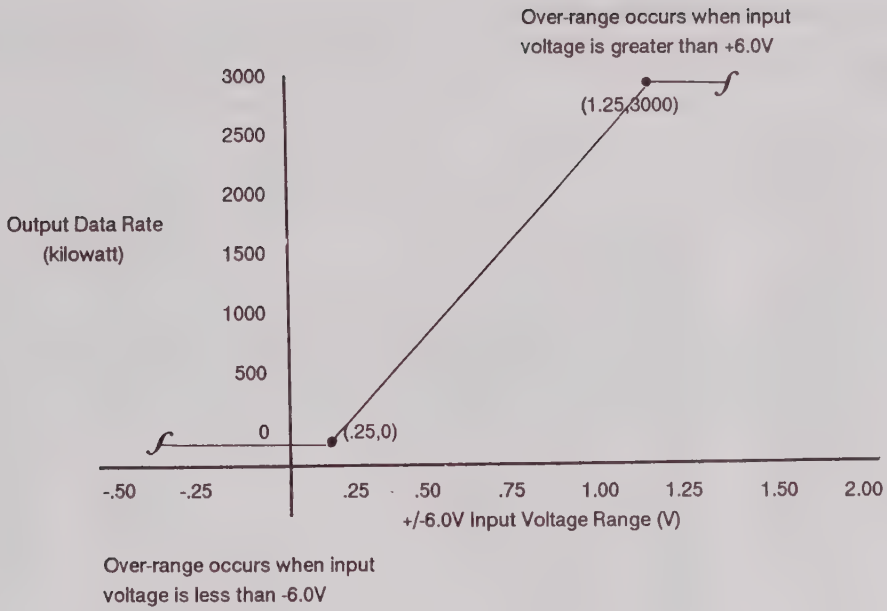
The induced voltage input at 20mA (1.2500V) is the maximum expected input voltage and determines the input voltage range of the linear function. She selects the 6.0000V range because it allows the best input resolution (.0001V or .1mV). She selects a clamped output to display a 0 KW reading at input currents below 4mA. Function Code 016 (6.0000V clamped linear input) is assigned.

She uses the induced voltages at 4mA and 20mA (.25V and 1.25V) and the corresponding kilowatt outputs (0 KW and 3000 KW) to define the endpoints, (X_1,Y_1) and (X_2,Y_2). The following values are assigned:

Input 1 = X_1 = 0.2500	Output 1 = Y_1 = 00000
Input 2 = X_2 = 1.2500	Output 2 = Y_2 = 03000

She does not redefine the decimal code because the default decimal location (00000.) is the desired resolution, but she does assign the letter K (kilowatts) to the units parameter.

Digi 4 Plus uses the two points (.25,0) and (1.25,3000) to compute the slope and to specify the endpoints. The system input data is converted from volts to an output in kilowatts. The resolution of the displayed output data is in whole units. Within the +/-6.0V input range of Function 017, the output data is clamped to 0 when the input is less than .25 V and to 3000 when the input is greater than 1.25 V. The output data is clamped at 0 KW if the current is lost or turned off. The figure on the following page shows the output data.


Over-range occurs when input
voltage is greater than +6.0V
3000
2500
2000
1500
1000
500
0
Output Data Rate
(kilowatt)
(1.25,3000)
(.25,0)
-.50
-.25
.25
.50
.75
1.00
1.25
1.50
2.00
+/-6.0V Input Voltage Range (V)
Over-range occurs when input
voltage is less than -6.0V

5.3.3 Thermocouple Functions (018-038)

Functions 018-038 measure input from a thermocouple. Filtering and Autocal can be applied.

Code	DVM Voltage Range	Type	Units	Temperature Range	Conformity
018	+/-30mV	B(Pt 30 Rh/Pt 6 Rh) (0.1F)	F	850F/+3289F*	+/-0.2F
019	+/-30mV	B(Pt 30 Rh/Pt 6 Rh) (0.1C)	C	+454C/+1809C*	+/-0.12C
020	+/-60.000mV	C(Tungsten 5 Re/Tung. 26 Re) (1.F)	F	-34F/+4159F	+/-0.18F
021	+/-60.000mV	C(Tungsten 5 Re/Tung. 26 Re) (0.1C)	C	-37C/+2293C	+/-0.1C
022	+/-60.000mV	E(Chromel-Constantan) (0.1F)	F	-164F/+1448F	+/-0.1F
023	+/-60.000mV	E(Chromel-Constantan) (0.1C)	C	-109C/+787C	+/-0.06C
024	+/-60.000mV	J(Iron-Constantan) (0.1F)	F	-169F/+2066F	+/-0.1F
025	+/-60.000mV	J(Iron-Constantan) (0.1C)	C	-112C/+1130C	+/-0.06C
026	+/-60.000mV	J (DIN Iron-Constantan) (0.1 C)	C	-201C/+901C	+/-0.1C
027	+/-60.000mV	K(Chromel-Alumel) (0.1F)	F	-149F/+2537F	+/-0.1F
028	+/-60.000mV	K(Chromel-Alumel) (0.1C)	C	-101/+1392C	+/-0.06C
029	+/-60.000mV	N(Nicrosil-Nisil) (0.1F)	F	-139F/+2364F	+/-0.1F
030	+/-60.000mV	N(Nicrosil-Nisil) (0.1C)	C	-95C/+1296C	+/-0.06C
031	+/-30mV	R(PT 13 Rh-Pt) (0.1F)	F	+505F/+3234F*	+/-0.18F
032	+/-30mV	R(PT 13 Rh-Pt) (0.1C)	C	+263C/+1779C*	+/-0.1C
033	+/-30mV	S(Pt 10 Rh-Pt) (0.1F)	F	+517F/+3212F*	+/-0.18F
034	+/-30mV	S(Pt 10 Rh-Pt) (0.1C)	C	+269C/+1767C*	+/-0.1C
035	+/-30mV	T(Copper-Constantan) (0.1F)	F	-363F/+755F	+/-0.1F
036	+/-30mV	T(Copper-Constantan) (0.1C)	C	-219C/+402C	+/-0.06C
037	+/-30mV	T(Copper-Constantan) (0.01C)	C	-112C/+341C	+/-0.02C
038	+/-30mV	T(DIN 43710 Cu-CuNi) (0.1C)	C	-211C/+599C	+/-0.1C

* For type B, R and S thermocouples, temperatures outside the given range can be off as much as +/-20C.

The open circuit test applies to all thermocouple functions.

Parameters

Source 1 is 000 for thermocouples directly connected to a Digi 4 Plus terminal bank. Digi 4 Plus uses a built-in thermocouple reference (located in each terminal bank) to determine the icepoint compensation voltage added to the reading before conversion to temperature.

When a thermocouple has a transition to copper leads at an external location or when a thermocouple voltage reading comes from a remote scanner, Source 1 is the address of the compensation voltage. When an external device generates the compensation voltage, the system assumes it is generated by a thermocouple whose measuring junction is at the ice-point temperature (0.0C) and whose terminals are at the same temperature as the terminals of the measuring thermocouples. Since this generates the negative of the appropriate reference compensation voltage, Digi 4 Plus subtracts rather than adds an external reference compensation voltage.

If the reference compensation voltage is system input data, assign Function Code 001 (Type C, E, J, K or N thermocouples) or Function Code 005 (Type B, R, S or T thermocouples) to the channel receiving the input.

If the thermocouple has an external ice-point reference compensation, the output data at the channel address or constant address specified by Source 1 should be 0 millivolts.

Source 2 is the address of the filter time constant.

Input 1, Output 1, Input 2 and Output 2 must be assigned values if Autocal is applied.
Units (F or C) are automatically assigned by Digi 4 Plus. You cannot redefine the decimal code.

Operation

Find the thermocouple type that matches your input and select Celsius or Fahrenheit output. (Type T thermocouples also let you specify the output resolution, 0.1C or 0.01C.) Assign the function code that includes both specifications. (Type J and Type T thermocouples have two standards, NBS and DIN.)

5.3.4 RTD Functions (039-046)

Functions 039-046 measure input from a 10 ohm copper RTD or a 100 ohm platinum RTD. Filtering and Autocal can be applied.

Code	DVM Voltage Range	Type	Units	Temperature Range	Conformity
039	+/-600.00mV	100 Ohm Pt (3-wire Bridge) (0.1F)	F	-193F/+1487F	+/-0.1F
040	+/-600.00mV	100 Ohm Pt (3-wire Bridge) (0.1C)	C	-125C/+808C	+/-0.06C
041	+/-60.000mV	100 Ohm Pt (3-wire Bridge) (0.01C)	C	-128C/+340C	+/-0.01C
042	+/-600.00mV	100 Ohm Pt (4-wire, 1mA) (0.1F)	F	-198F/+1570F	+/-0.1F
043	+/-600.00mV	100 Ohm Pt (4-wire, 1mA)(0.1C)	C	-128C/+854C	+/-0.06C
044	+/-600.00mV	100 Ohm Pt (4-wire, 1mA) (0.01C)	C	-127C/+441C	+/-0.01C
045	+/-60.000mV	10 Ohm Cu (3-wire Bridge) (0.1F)	F	-325F/+519F	+/-0.1F
046	+/-60.000mV	10 Ohm Cu (3-wire Bridge) (0.1C)	C	-198C to +271C	+/-0.06C

You can connect three-wire 100 ohm platinum and 10 ohm copper RTD's directly to a Kaye RTD scanner (Model V2235) mounted on the mainframe. The RTD scanner provides the required excitation voltage and completion resistors for up to 16 RTD's. Or you can connect RTD's to a Kaye analog scanner (Model V2221) mounted on the mainframe unit if they are externally conditioned.

To process an input from a 10 ohm copper RTD, use a Kaye Bridge Conditioner (BC-8). To process an input from a 100 ohm platinum RTD, use a Kaye Bridge Conditioner (3-wire or 4-wire RTD) or a 1ma Constant Current Supply (4-wire RTD only).

Digi 4 Plus measures the voltage output from the bridge and converts it to temperature. It measures excitation voltage from the 1mA Constant Current Supply and converts it to temperature. An open lead between the RTD and either the Bridge Conditioner or the Constant Current Supply creates an open circuit.

Function Code 041 requires a special high accuracy bridge. See the documentation supplied with the Bridge Conditioner and make the following adjustments: Resistors (R1 and R2) require a value of 5.5K and Resistor (R6) requires a value of 332K.

Parameters

Source 1 is not used. Source 2 is the address of the filter time constant.

Input 1, Output 1 and Input 2, Output 2 must be assigned values, if Autocal is applied to the function.

Units (F or C) are automatically assigned. You cannot redefine the decimal code.

Operation

Find the appropriate RTD type. With a 10 ohm copper RTD, select Celsius or Fahrenheit output. With a 100 ohm platinum RTD, determine whether the RTD is excited by a Bridge Conditioner or Constant Current Supply and select Celsius or Fahrenheit output. For Celsius output, specify 0.1 or 0.01 resolution.

5.3.5 Multi-Segment Input Functions (047-050)

Functions 047-050 perform a segmented curve fit on non-linear system input and convert the voltage reading into engineering units. Unlike linear input functions, scaling is not restricted to a single, straight-line relationship. The multi-segment input functions use several straight-line segments to perform the scaling. Autocal can be applied.

Code	Range	Output Constraint Type
047	+/-60.000 mV	Bounded
048	+/-600.00 mV	Bounded
049	+/-6.0000 V	Bounded
050	+/-12.000 V	Bounded

Operation

Determine the maximum voltage expected and select the function code that supports the maximum input.

Define a series of points (segment endpoints), by assigning values to input/output parameters at consecutive constant addresses. The system calculates the slope for each pair of defined points, directs system input data to the channel assigned the multi-segment input function; and converts system input data using the appropriate adjacent pair of user-defined points.

The first point must have the lowest input value. Each successive endpoint must have a greater value than the preceding one. (This restriction does not apply to the output parameter.) The decimal resolution in all input constants must match the Source 1 data. The decimal point in all output constants must be in the same location. The input voltage range does not govern this decimal point location.

System input data that falls between values assigned to two input constants at two consecutive constant addresses is linearized by the segment defined by these endpoints. If the system input data is less than the input of the first point or greater than the input of the last point, the output data goes over-range.

You can define up to 98 segments using all 99 constant addresses. Each successive value assigned a constant address must be greater than the preceding one. (Output constants are not restricted by this limitation.)

To end the function, assign NULL to the input parameter at the constant address immediately after the one with the last point.

Parameters

Source 1 is 000 unless an offset value is required. If a channel address is assigned to Source 1, the system subtracts the value at that address from the system input voltage. (This feature can specify the compensation voltage for a custom thermocouple curve fit.) Source 2 is a constant address that specifies the first point. You must assign an input and output constant to each constant address that specifies an endpoint in a segment.

Input 1, Output 1 and Input 2, Output 2 must be assigned values, if Autocal is applied.

The decimal default location is 00000. You can redefine the decimal code and assign units.

Multi-segment input functions output extended precision data and displayed data.

Example: Assign Function 047 (60.000mV multi-segment input function) to Channel Address 301. System input data comes from a flow transducer. The flow transducer has the following characteristics that define the segment endpoints.

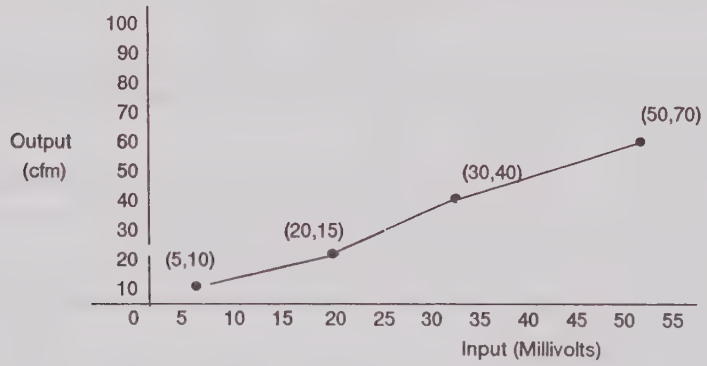
Voltage	Flow
5mV	10 cfm
20mV	15 cfm
30mV	40 cfm
50mV	70 cfm

Source 1 is 000. No offset voltage is required. Source 2 is 040, the constant address of the first point in the function. Assign the following values to consecutive constant addresses, beginning with Constant Address 40.

Constant Address	Input	Output
40	05.000	00010
41	20.000	00015
42	30.000	00040
43	50.000	00070
44	NULL	

All input constants have the same decimal location as the input voltage range. All output constants must have the same decimal location. The decimal code defines the decimal location in the displayed data (0000.0). You can assign units.

The figure below shows the interconnecting segments that result from these assignments.



Channel input data between 5mV and 20mV is converted to cfm according to the linearization defined by the endpoints (5,10) and (20,15). Input data between 20mV and 30mV is converted to cfm according to the linearization defined by the endpoints (20,15) and (30,40), and input data between 30mV and 50mV is converted to cfm according to the linearization defined by the endpoints (30,40) and (50,70).

If the input data is less than 5mV or greater than 50mV, an over-range occurs.

5.4 LINEAR TRANSFER FUNCTIONS (051-053)

Functions 051-053 scale the output of another channel, including thermocouple and RTD measurements, remote inputs (BC-8, FS-8, DS-8) and calculations.

Code	Output Constraint Type
051	Un-bounded
052	Bounded
053	Clamped

Scaling must have a single, straight-line relationship. Linear transfer functions operate like linear input functions (but linear input functions use system input data). Linear transfer functions accept extended precision and displayed data. They can multiply/-divide and add/subtract at one channel address. Filtering and Autocal can be applied.

Parameters

Source 1 is the address of the input data. Source 2 is the address of the filter time constant.

Input 1, Output 1, Input 2, and Output 2 are two known input/output points, (X_1,Y_1) and (X_2,Y_2).

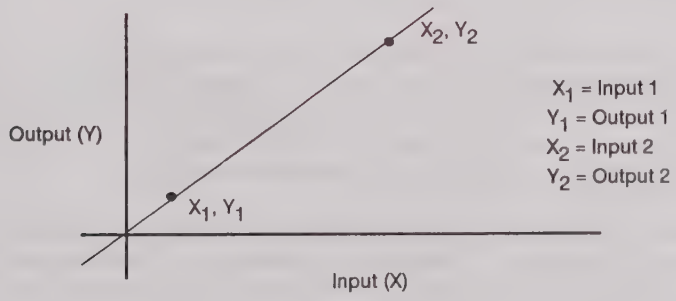
The decimal defaults to the rightmost position unless redefined. You can assign units.

Operation

The system converts input data to the desired output by setting up a direct correspondence between the channel input and output data, (X_1,Y_1) and (X_2,Y_2). Assign values to the Input 1, Output 1, Input 2 and Output 2 parameters to define these points.

Input 1 = X_1 Output 1 = Y_1
Input 2 = X_2 Output 2 = Y_2

Digi 4 Plus uses the points defined by (X_1,Y_1) and (X_2,Y_2) to compute the slope and intercept of the function and convert the input data.



The Input 1 and Input 2 decimal points must be in the same position. The Output 1 and Output 2 decimal points must be in the same position.

The decimal code defines the resolution of the displayed output data. The resolution, in turn, determines the maximum value of the displayed data. When displayed data exceeds the display capacity, an over-range occurs.

Linear transfer functions output extended precision and displayed data. If the displayed data goes over-range, extended precision data may still be valid input data for a channel that accepts extended precision input.

If the input data specified by Source 1 goes open or over-range, both the displayed data and extended precision data go over-range.

You can also assign a linear transfer function to a channel to multiply or divide input data by one constant and add or subtract a second constant to the result. When you use the linear transfer function to perform two mathematical operations at one channel, assign Function 051 (unbounded linear transfer).

A linear transfer function can evaluate the output of the equation $\mathbf{y = mx_1 + b}$, where m and b are constants and x_1 is any value of input data from Source 1.

To divide the input by a constant, express m in decimal form. For example, m equals .25 if you want to divide an input by 4. If you want to subtract a value from mx_1, b is a negative number.

If you use a linear transfer function to perform two mathematical operations, assign the following values to the input/output parameters:

Input 1 = $X_1 = 0$ (The function is most easily implemented when $X_1 = 0$.)
Output 1 = $Y_1 = b$
Input 2 = X_2 = any non-zero value in input data range (x_1)
Output 2 = $Y_2 = mX_2 + b$

The decimal in the displayed data defaults to the rightmost position unless redefined.

Un-bounded, Bounded or Clamped Linear Transfer Functions

The Un-bounded Linear Transfer Function (051) follows the linear relationship until the display capacity is exceeded and the displayed output data goes over-range. Extended precision data can be used by another channel that accepts extended precision input.

The Bounded Linear Transfer Function (052) follows the linear relationship until the input data is outside the range defined by Input 1 and Input 2. Always define the Input 1 value as less than the Input 2 value. When the input data goes outside this range, the displayed and extended precision output data go over-range.

The Clamped Linear Function (053) follows a linear relationship until the input data is outside the range defined by Input 1 and Input 2. Define the Input 1 value as less than the Input 2 value. If the input data goes outside this range, the system sets the output data equal to Output 1 when the input data is less than Input 1, and sets the output data equal to Output 2 when the input data is greater than Input 2.

Example: Suppose you want to display the molasses example we used earlier as a flow rate of gallons per day with a 1. resolution, in addition to the flow rate of gallons per hour, with 0.1 resolution. The output from the linear input function, gallons per hour, is the input data to the channel assigned the linear transfer function.

You can compute the output, gallons per day, by simple arithmetic. A flow rate of 30 gallons per hour corresponds to 720 gallons per day; a flow rate of 200 gallons per hour corresponds to 4800 gallons per day.

Assign Function Code 052 (bounded linear transfer) to a channel with the following

parameters:

Source 1 = The address measuring the flow rate per hour
Input 1 = X_1 = 00030 Output 1 = Y_1 = 00720.
Input 2 = X_2 = 00200 Output 2 = Y_2 = 04800.
Decimal Code = 00000.

The channel assigned this function goes over-range when the input data is outside the range of Input 1(30) to Input 2(200).

If we had selected Function Code 053 (clamped linear transfer), the output data would be 720 when the input data was less than Input 1(30); the output data would be 4800 when the input data was greater than Input 2(200).

If we had selected Function Code 051 (unbounded linear transfer), the output data would follow a linear relationship until the display capacity was exceeded (+/-65535.) and the displayed output went over-range. Extended precision output would still be valid and could be used by a channel that accepts extended precision input.

5.5 MULTI-SEGMENT TRANSFER FUNCTION (054)

Function 054 performs a segmented curve fit on non-linear input. Unlike linear transfer functions, it uses several straight-line segments for scaling. The multi-segment transfer function outputs extended precision and displayed data. Autocal can be applied.

Operation

Define a series of points (segment endpoints) by assigning values to the input and output parameters at consecutive constant addresses. Each end-point must have a greater input value than the preceding one. (This restriction does not apply to the output parameter.) The first point must have the lowest input value.

The decimal point in all input constants must match the Source 1 data. The decimal in the output constants can be in any position; however, all output constants must have the same decimal position. The decimal code determines the decimal location in the displayed output data.

Input data that falls between the values assigned to two input constants at two consecutive constant addresses is linearized by the segment defined by these endpoints. If it is less than input of the first point or greater than input of the last, the output data goes over-range.

You can define up to 98 segments using the 99 constant addresses. The input value assigned a constant address must be greater than the input value assigned the preceding constant address. (Output constants are not restricted by this limitation.)

To end the function, assign NULL to the input parameter at the constant address immediately following the one specifying the last point. The system calculates the slope for each pair of defined points; transfers the displayed data specified by Source 1 to the channel assigned the multi-segment transfer function; and converts the Source 1 data using the appropriate adjacent pair of user-defined points.

Parameters

Source 1 is the channel address of the displayed input data to be scaled. Source 2 is the constant address that specifies the first point in the function. Each constant address that specifies an endpoint in a segment must have an input value and an output value.

Input 1, Output 1 and Input 2, Output 2 must be assigned values, if Autocal is applied.

The decimal defaults to the rightmost position unless redefined. You can assign units.

5.6 DATA ACCUMULATION FUNCTIONS (055-058)

Functions 055-058 integrate and totalize the displayed data from a source channel for a user-defined interval. The data at the source channel can be rate data with any time base (per minute, per hour or per day). Open circuit or over-range readings are not added to the accumulation total.

Code	Description
055	Does not print or transmit the accumulation output
056	Prints a single line of accumulation output
057	Transmits a single line of accumulation output
058	Prints and transmits a single line of accumulation output

These functions differ only in their output format. However, CALC channels do not accept Function 056-058.

Operation

Digi 4 Plus accumulates data from the source channel every 10 seconds or at the end of each math scan. It stores the full resolution of the data in an accumulation register, but outputs only displayed data. The accumulation function continues to accumulate the data until the reset logic bit makes a false to true transition. At reset, the accumulation register can reset to zero or the function can subtract the displayed total from the accumulation register. If the function is configured to subtract the displayed total from the accumulation register, whatever remains in the accumulation register becomes the initial value of the next accumulation total.

Since the accumulation functions output only displayed data, the displayed total must fit within the display capacity (+/-65535). If you calculate that the total will exceed the display capacity, use the scale factor to convert from units to kilo-units or mega-units. The system multiplies the data in the accumulation register by the scale factor and rounds off the last digit to the nearest whole number. The scale factor is also used for time scaling and measure scaling.

Time Scaling is required if your input data is rate data expressed in a time base other than per minute (such as gallons per hour or kilograms per day) or if the output data has units of time other than minutes (such as kilowatt-hours).

Measure Scaling is required if you want to accumulate data in units different than those of the input data. For example, if the input data is KW hours and you want to display BTU's, use the scale factor to convert the units from KW hours to BTU's.

The system can print or transmit a one line accumulation total before it resets the accumulation register. If you want a report at the end of the accumulation interval, use the same logic address that resets the accumulation interval to generate the report. See Configuration Code Address 010, 020, 030 or 040 for more information.

Parameters

Source 1 is the channel address of the input data. Source 2 is a logic address that resets the accumulation interval. When this logic bit goes from false to true, the accumulation register either resets to zero or subtracts the displayed data from the accumulation register.

Output 2 determines how often input data is added to the accumulation register and

whether the accumulation register is reset to zero or the displayed total is subtracted from the accumulation register. Select one of the following:

OUTPUT 2 > 0	Accumulate data every math scan and clear accumulation register to zero at reset
OUTPUT 2 = 0 (or undefined)	Accumulate data every 10 seconds and clear accumulation register to zero at reset
OUTPUT 2 = -0	Accumulate data every 10 seconds and subtract displayed total from accumulation register at reset
OUTPUT 2 < -0	Accumulate data every math scan and subtract displayed total from accumulation register at reset

We recommend that you set up the function to accumulate data every math scan (unless you are accumulating data from an FS-8) because it provides a more timely sampling of input changes. Also configure the function to subtract the displayed total from the accumulation register if you don't want a cumulative error to occur in the sum of a series of accumulation totals.

Input 1, Input 2 and Output 1 define the scaling factor. If undefined, they default to an effective value of 1.

The decimal in the output data defaults to the rightmost position unless redefined.

The formula for scaling is:

$$\text{Scale factor} = \frac{\text{Output 1}}{\text{Input 1} \times \text{Input 2}}$$

We recommend Input 1 for measure scaling, Input 2 for time scaling and Output 1 for display scaling.

Time scaling is required if your input data is expressed in a time base other than per minute, such as per hour or per day.

Time Value	Input 2 Value
Per minute	00001
Per hour	00060
Per day	01440

Measure scaling is required if the units displayed in the accumulation total are different from those of the input data.

Set Input 1 equal to a single unit of output measure. For example, if the input data is in liters and you want to display the accumulation output in gallons, assign 3.7854 to Input 1 (a 3.7854 liter input equals a 1 gallon output).

If Input 1 cannot be expressed directly with sufficient resolution, multiply Input 1 by 1000 and Input 2 by 0.001. If the value of Input 1 exceeds the display capacity, multiply Input 1 by 0.001 and multiply Input 2 by 1000. For example, if the input data is in gallons and you want to display the accumulation total in liters you cannot directly assign 0.26417 to Input 1 (0.26417 gallons of input equals a 1 liter of output) without losing resolution. You must split the value and assign 0.26417 x 1000 = 264.17 to Input 1

and multiply Input 2 by 0.001.

Display scaling is required if the accumulation total cannot fit the display capacity.

Use the maximum output magnitude check, which calculates the maximum expected value of the accumulation output (A), to see if it fits.

$$A = \frac{\text{Max input(magnitude) x Max interval(minutes) x Output 1}}{\text{Input 1 x Input 2}}$$

Max input = Max attainable magnitude of input data
Max interval = Max number of minutes data is to be accumulated

Table 5-1 shows accumulation output ranges. Find the range for A and multiply Output 1 and Input 2 by the value in those columns.

Decimal code defines the resolution in the accumulation output. Values in this column indicate the maximum achievable resolution (shown in the maximum resolution column). Units identifies the accumulation output as units (U), kilo-units (K) or mega-units (M).

Table 5-1. Accumulation Output Ranges

A= Max expected magnitude of accumulation output	Output 1	Input 2	Decimal Code	Maximum Resolution	Units
0<A≤6.5535	---	X 1	0.0000	0.0001	U
6.5535<A≤65.535	---	X 1	00.000	0.001	U
65.535<A≤655.35	---	X 1	000.00	0.01	U
655.35<A≤6,553.5	---	X 1	0000.0	0.1	U
6,553.5<A≤65,535	---	X 1	00000.	1.	U
65,535<A≤655,350	0.001	X 1	000.00	0.01	K
655,350<A≤6,553,500	0.001	X 1	0000.0	0.1	K
6,553,500<A≤65,535,000	0.001	X 1	00000.	1.	K
65,535,000<A≤655,350,000	0.001	X 1000	000.00	0.01	M
655,350,000<A≤6,553,500,000	0.001	X 1000	0000.0	0.1	M
6,553,500,000<A≤65,535,000,000	0.001	X 1000	00000.	1.	M

For less resolution, redefine the decimal code.

Example 1: Accumulate data with a full-scale input of 5000.0 grams per hour for 800 hours at Channel 501. Assign Function Code 056 so the system prints the accumulation total at the end of the interval. The input data is from Channel 411; the system accumulates data from Channel 411 every math scan. The accumulation interval is reset by the logic bit at Status Input 081.

Time scaling required to convert grams per hour to per minute. (Input 2 = 00060)
Measure scaling not required (Input 1 = 00001)
Display scaling. Calculate the maximum expected magnitude of the total (A).

$$A = \frac{\text{Max input x Max interval (min) x Output 1}}{\text{Input 1 x Input 2}}$$

$$A = \frac{5000.0 \times (60 \times 800) \times 1}{1 \times 60} = 4{,}000{,}000$$

Refer to A in Table 5-1 and:

- o Multiply (Output 1) X 0.001
- o Assign 0000.0 to decimal code
- o Change units to kilograms
  Maximum output resolution = 0.1 Kg.
  Maximum accumulation output = 4000.0 Kg.

Final values assigned to Channel 501:

Function Code = 056	Decimal Code = 0000.0
Source 1 = 411	Source 2 = 081
Input 1 = 00001	Input 2 = 00060
Output 1 = 00.001	Output 2 = 00001
Units = K (kilograms)	

Example 2: Accumulate data with a full-scale input of 4500.0 cubic centimeters per hour for 1 month at Channel 203. Display the accumulation output in kilo-liters. Assign Function Code 055; a one line total is not required at the end of the interval. The input data is from Channel 604; the system accumulates data from Channel 604 every math scan. The accumulation interval is reset by System Timer 03 with a reset at the end of the month. (System Timer 03 controls Logic Address 903.)

Time Scaling required to convert cubic centimeters per hour to per minute. (Input 2 = 00060)

Measure Scaling required to convert from cubic centimeters to kilo-liters. Input 1 = the amount of input measure required for a single unit of output measure (1,000,000 cc = 1 kilo-liter).

1,000,000 is greater than the display capacity of +/-65535. Assign 1,000 (1,000,000 x .001) to Input 1 and multiply Input 2 by 1000 (60 x 1,000 = 60,000).

Input 1 = 01000 and Input 2 = 60000

Check Display Scaling and Resolution. Calculate the maximum expected magnitude of the accumulation output (A).

$$A = \frac{\text{Max input x Max interval(min) x Output 1}}{\text{Input 1 x Input 2}}$$

$$A = \frac{4500.0 \times (31 \times 24 \times 60) \times 1}{1000 \times 60{,}000} = 3.3480 \text{ KL}$$

Refer to A in Table 5-1. No display scaling is required.
Output 1 = 00001 Decimal code = 0.0000
Maximum output resolution = 0.0001 KL
Maximum accumulation output = 3.3480 KL

For 0.001 output resolution, assign 00.000 to the decimal code. The maximum accumulation output = 3.348 KL.

Final values assigned to Channel 203:

Function Code = 055	Decimal Code = 0.0000
Source 1 = 604	Source 2 = 903
Input 1 = 01000	Input 2 = 60000
Output 1 = 00001	Output 2 = 00001
Units = K (kilo-liters)	

Example 3: Accumulate data with a full-scale input of 2400.0 KW for 3 months at Channel 508. Display the accumulation output in BTU's. Assign Function Code 057 so system transmits a single line of accumulation total at the end of the interval. The input data is from Channel 315; the system accumulates data from Channel 604 every math scan. The accumulation interval is reset by the logic bit at Channel 711.

Time Scaling not required since KW can be expressed as KW-min/min. (Input 2 = 00001)

Measure Scaling required to convert from kilowatt-minutes to BTU's: Input 1 = the amount of input measure required for a single unit of output measure.

0.017581 KW-min = 1 BTU

Since you cannot enter 0.017581 directly without losing resolution, assign (0.017581 x 1000) 17.581 to Input 1 and (1 x 0.001) 0.001 to Input 2.

Check display scaling and resolution. Calculate the maximum expected magnitude of the accumulation output (A).

$$A = \frac{\text{Max input x Max interval(min) x Output 1}}{\text{Input 1 x Input 2}}$$

$$A = \frac{2400.0 \times (24 \times 60) \times (2 \times 31 + 30) \times 1}{17.581 \times 0.001} = 18{,}084{,}978{,}000$$

Refer to A in Table 5-1 and

- Multiply Output 1 by 0.001 and multiply Input 2 by 1000
- Assign decimal code = 00000
- Change units to Mega-BTU's
  Maximum output resolution = 1 M BTU
  Maximum accumulation output = 18283 M BTU

Final values assigned to Channel 508:

Function Code = 057	Decimal Code = 00000.
Source 1 = 315	Source 2 = 711
Input 1 = 17.581	Input 2 = 00001
Output 1 = 00.001	
Units = M (Mega-BTU's)	

5.7 METER FUNCTION (059)

For some metering applications (such as the measurement of gas flow) accumulation functions are not satisfactory because they have a maximum value of 65535 and must be reset periodically. Function 059 uses two consecutive channels to provide an eight-digit display (XX.XXX.XXX). The system will not accept Function Code 059 at a channel unless the next higher addressed channel has Function Code 000. When you assign the meter function to a channel, the system automatically assigns Function Code 211 to the next higher channel.

CALC channels do not accept Function Code 059.

Parameters

Source 1 is the channel address of the input rate data. Source 2 is a logic address. When the logic bit at the Source 2 address makes a false/true transition, the meter is reset to all zeros.

Output 1 is the maximum count value of the data at the channel address assigned Function Code 059. If Output 1 is undefined, 9999 is the default value. Output 2 is the time base in minutes of the input rate data. If Output 2 is undefined, the default is a per minute time base.

You can assign units.

Operation

The meter function is designed so each channel address normally displays four digits. If Output 1 is undefined or 9999, the digits at each channel address increment to 9999 and then reset to zero. Each ten-second interval the meter function adds one sixth of the input data value (divided by 1000 x Output 2) to the displayed data.

Depending on the input data, the displayed data at the second channel is rarely either 9.999 or 0.000. For example, if the source data is 600., the value may go from 9.986 to 0.086. Conceptually, however, the meter counts to 9999, resets to 0000 and counts back to 0086 in one reading. The meter function is a continuously accumulating or wrap-around function that is reset only by the logic bit specified by the Source 2 address.

Use the meter function with one or more counter functions (060) to extend the meter display from eight digits to as many digits as desired.

The data at the Function 211 channel always increments to 9999, resets to zero and continues to count. When the data at the Function 211 channel resets to zero, the data at the Function 059 channel is incremented by 1. The example is for input data equal to 600.)

Display at Function 059 Channel	Display at Function 211 Channel		Display at Function 059 Channel	Display at Function 211 Channel
12.55	9.986	next 10-sec scan	12.56	0.086

The data at the Function Code 059 channel increments to 9999 or the value assigned to Output 1, resets to zero and continues to count. When the data at the Function Code 059 channel resets to zero, the logic bit at that channel address can be set true during

the next math scan if you assign a low limit of zero and Limit Op-Code 2 specifies the channel logic bit is turned on. Use the counter function (060) to totalize these transitions in order to extend the metering display.

Display at Function 059 Channel	Display at Function 211 Channel		Display at Function 059 Channel	Display at Function 211 Channel
99.99	9.986	next 10-sec scan	000.00	00.086

The decimal location at the Function 211 channel is 00.000; the decimal location at the Function 059 channel is 000.00. The data at the Function 211 channel represents kilo-units (where the last digit is a unit of the input data) and the data at the Function 059 channel represents mega-units.

The input data may have a finer resolution than that of the units totalized. For example, the input rate data may have a resolution of tenths, hundredths or thousandths. A special register keeps track of the fractional portion of a unit. When the fractional portion equals one whole unit, the value added to the totalized units represents the full resolution of the input data.

5.8 COUNTER FUNCTION (060)

Function 060 totalizes the number of times a logic bit makes a false/true transition. Each transition increments the counter by one.

Parameters

Source 1 is the address of the logic bit totalized. Source 2 is the address of the logic bit that resets the counter. There is no decimal point in the output data.

Operation

Each false/true transition specified by the Source 1 address increments the counter by one. When the logic bit specified by the Source 2 address makes a false/true transition, the counter resets to all zeros on the next math scan. This allows the system to transfer the totalized value to another channel and/or include it in a report. (See Functions 114-115). The counter remains at zero until the Source 2 logic bit goes false.

If the logic bit specified by the Source 2 address does not make a false/true transition, the counter resets when the total reaches 65535.

You can enter limits at a channel assigned the counter function. When the limit is exceeded, the channel logic bit goes on. The counter function may reset itself if you specify Source 2 as the channel assigned the counter function.

5.9 INTERVAL FUNCTIONS (061-064)

Functions 061-064 calculate the average, maximum value or minimum value of the displayed data from Source 1 during an interval specified by Source 2. The rate-of-change calculation is based on the current change and the previous calculated change.

Code	Description
061	Calculates average value
062	Calculates maximum value
063	Calculates minimum value
064	Calculates rate-of-change

Parameters

Function Codes 061-063. Source 1 is the channel address of the input data. Source 2 is a logic address, usually a system timer. When the logic bit specified by the Source 2 address makes false/true transition, another time interval begins.

Function 064. Source 1 is the channel address of the input data. Source 2 is the address of the filter time constant.

Output 1 defaults to 1, which is a per second time base. To change the time base, assign the number of seconds in the time base to Output 1. For example, to express a rate of change in a per minute time base, assign 60 to Output 1.

The decimal defaults to the rightmost position unless redefined. You can assign units.

Operation

Function Code 061 computes the average of the Source 1 data over the time interval specified by Source 2. Samples of input data are taken every analog scan and added to all previous samples. This total is divided by the number of samples. The total is cleared at the end of the time interval.

Open or over-range samples are not included in the interval average; the function only averages valid data. If the input data is either open or over-range at the beginning of the interval, the channel output data reads over-range. The output data remains over-range until a valid sample of input data is found; then sampling begins and the channel output data reflects the interval average.

Function Code 062 selects the maximum value of Source 1. The first sample is stored as the maximum value at the beginning of the interval. Each successive sample is compared to the maximum value. (A sample is taken every math scan.) If the current sample is greater than the stored value, it becomes the new stored maximum value.

To display the time at which the maximum value occurred, assign an optional Function Code 100 to the following channel. The time is displayed in an hour, minute and tens of second format (HHMM.S). For example, 9:15:30 P.M. = 2115.3

Function Code 063 selects the minimum value of Source 1. At the beginning of the interval, the first sample is stored as the minimum value. Each successive sample is compared to the minimum value. (A sample is taken every math scan.) If the current sample is less than the stored value, it becomes the new stored minimum value.

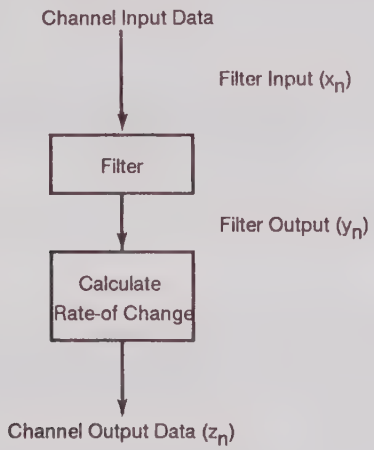
To display the time at which the minimum value occurred, assign Function Code 100 to the following channel. The time is displayed in an hour, minute and tens of second format (HHMM.S). For example, 6:45:50 A.M. = 0645.5

Example: Use interval functions to determine the average, maximum and minimum daily temperatures. The temperature is monitored at Channel 107. Specify Source 1 as Channel 107; specify Source 2 as System Timer 02, which is set for a 24 hour time interval with a reset time of midnight.

Channel Address	210	211	212
Function Code	061	062	063
Source 1	107	107	107
Source 2	902	902	902

The average daily temperature is displayed at Channel 210, the maximum daily temperature is at Channel 211 and the minimum daily temperature is at Channel 212.

Function Code 064 calculates the amount input data changes per analog scan. Filtering can be applied to the input data before the rate-of-change is calculated.



Digi 4 Plus uses the following algorithm to calculate filtering on the rate-of-change function:

$$y_n = y_{n-1} + \frac{(x_n - y_{n-1})}{1 + (\text{Filtertime}/\text{Scantime})}$$

Where:

y_n = New filter output
x_n = Current filter input
y_{n-1} = Last filter output
Filtertime = Filter time constant in seconds
Scantime = Analog scan time in seconds (sample interval) displayed at Channel 911

After the input data is filtered, the rate-of-change is calculated according to the following equation:

$$z_n = \frac{y_n - (y_{n-1})}{\frac{\text{Scantime}}{K}}$$

Where:

z_n = Channel output (rate-of-change)
K = Seconds in time base. K defaults to 1; the rate-of-change is expressed per K seconds.

5.10 ELAPSED TIMER FUNCTIONS (065-066)

Functions 065 and 066 measure how long a logic bit is true or false.

Code	Description
065	Measures the elapsed time of a true logic bit
066	Measures the elapsed time of a false logic bit

Parameters

Source 1 and Source 2 are logic addresses. The logic bits at the Source 1 and Source 2 addresses control the operation of the elapsed timer. The logic bit at the Source 1 address is the run bit, and the logic bit at the Source 2 address is the reset bit.

Output 1 is the time scaling factor. It defaults to 1. Although the elapsed time defaults to seconds, the system can display the elapsed time in another unit of time (minutes or hours). Simply assign the appropriate number of seconds to Output 1. For example, to display the elapsed time in minutes, assign 60 to Output 1.

The decimal defaults to the rightmost position unless redefined. You can redefine it to show 0.1, 0.01, 0.001 or 0.0001 resolution. When the time is displayed in seconds, 0.1 is the most accurate resolution.

Operation

Function Code 065 keeps track of how long a logic bit is true. At the beginning of each math scan, the system looks at the logic bits specified by Source 1 and Source 2. While the run bit (Source 1) is true, the function adds the value of each math scan time to the elapsed timer until the reset logic bit (Source 2) makes a false/true transition. The elapsed timer stops, but does not reset when the run bit is false.

The math scan time is computed to an accuracy of 0.01 seconds and is displayed at Channel 910.

Function Code 066 keeps track of how long a logic bit is false. At the beginning of each math scan, the system looks at the logic bits specified by the Source 1 and Source 2 logic addresses. While the run bit (Source 1) is false, the function adds the value of each math scan time to the elapsed timer until the reset logic bit (Source 2) makes a false/true transition. The elapsed timer stops, but does not reset when the run bit is true.

For both function codes, a false/true transition of the reset logic bit sets the elapsed timer to zero during the math scan following the transition. This lets you transfer the totalized value to another channel and/or include it in a report.

You can use the output of an elapsed timer to define a value of a pre-programmed ramp and soak by using the accumulated time as input to a multi-segment transfer function.

The logic bit that resets the elapsed timer can also reset an accumulation function. For example, this bit can be set from an external contact closure or the output of a system timer.

You can enter limits at a channel assigned an elapsed timer function. When the limit is exceeded, the channel logic bit goes on if specified in Limit Op-Code 2. If you assign the channel logic bit as the address of the reset bit, an elapsed timer can reset itself.

If the time value exceeds the display capacity of the system, an over-range occurs. An elapsed timer does not automatically reset to zero when an over-range occurs and it maintains its data value if a power failure occurs.

5.11 HISTORICAL BUFFER FUNCTIONS (067-074)

Functions 067-074 select samples and values or compute the average and/or standard deviation of samples stored in the buffer. See Section 6 for more information on historical buffers.

Code	Description
067	Computes the average of the samples
068	Selects the maximum value of the samples
069	Selects the minimum value of the samples
070	Selects the nth sample, where n = Source 2
071	Selects the four highest sample values
072	Computes sum of the samples
073	Computes standard deviation of the samples
074	Clears historical buffer of all samples

Function Codes 067-073

Parameters

Source 1 is the address of the historical buffer. For Function Codes 067-069 and 071-073, Source 2 is the number of buffer samples used in the calculations or selections. For Function Code 070, Source 2 is the number of a specific (nth) sample.

The decimal defaults to the rightmost position unless redefined.

Historical buffers are cleared when the system is initialized. If you specify a buffer as a storage location for another historical buffer function, we recommend assigning the clear buffer function to be sure all data samples are from the same channel address.

Each historical buffer has two sources. Source 1 is the address of the channel from which the data samples are taken. Source 2 is the time interval between each sample entry.

Operation

An historical buffer function operates on data samples from one channel address. The samples are updated per the specified time interval. The system uses the most recent of up to 32 samples to:

1. Compute the average, sum and standard deviation (σ) of a specified number of samples in an historical buffer. Use the following equation for the standard deviation function.

$$\sigma = \sqrt{\frac{1}{N} \sum_{1}^{N} (x_n - x)^2}$$

N = Number of samples
n = Sample number
x_n = Value of the nth sample
x = Average of all samples

2. Select the maximum, minimum and/or four highest values from a specified number of samples in an historical buffer.

The channel assigned Function Code 071 displays the highest of the four values. Assign Function Code 100 at up to three channels following the Function Code 071 channel to give the second highest, third highest and fourth highest value of the samples.

3. Display the value of a specific (nth) sample in an historical buffer.

Over-range or open circuit readings are not included in computations or selections. For example, if you specify 10 samples and 2 are open or over-range, the system uses 8 samples. Until you enter a numeric value for a specific sample number, data is considered open circuit.

Redefine the decimal code for best resolution. If the display capacity is exceeded, extended precision data is still valid.

Function Codes 068 to 071 output displayed data. Function Codes 067, 072 and 073 output extended precision data and displayed data.

Example: Determine the average, maximum and minimum temperatures of a refrigeration unit over 60 minutes with a 2 minute update.

The temperature readings are stored at Historical Buffer 012. Specify Source 1 as 012. Thirty samples are used. Specify Source 2 as 030.

Channel Address	210	211	212
Function Code	067	068	069
Source 1	012	012	012
Source 2	030	030	030

Assign two sources to Historical Buffer 012. Specify Source 1 as 107 and Source 2 as 905. Source 1 is the channel address monitoring the temperature. Source 2 is a system timer assigned a 2 minute time interval.

Channel 210 displays the average temperature, Channel 211 the maximum temperature and Channel 212 the minimum temperature. In this example, the system uses the last 30 samples for its calculations. A new sample enters Historical Buffer 012 every 2 minutes. Open circuit or over-range readings in the last 30 samples are disregarded.

Function Code 074

When you assign a clear buffer function, the system enters all open values in the historical buffer when the logic bit specified by Source 2 makes a false/true transition.

Parameters

Source 1 is the address of the historical buffer. Source 2 is the address of the logic bit that controls the clearing of the buffer.

Displayed data at a channel address assigned this function reflects the state of the logic bit (Source 2 address). When it is false, the display contains 0.00. When it is true, the display contains 1.00.

5.12 GROUP FUNCTIONS (075-081)

Functions 075-081 compute averages, sums and standard deviation or select values from consecutively addressed channels. Samples of input data are taken every math scan.

Code	Description
075	Computes average of a group of channels
076	Selects maximum value from a group of channels
077	Selects minimum value from a group of channels
078	Selects the four highest values from a group of channels
079	Selects the four highest values from a group of channels; channel addresses generating these values can also be displayed, printed and/or transmitted
080	Computes the sum of a group of channels
081	Computes the standard deviation of a group of channels

All input data in the group must have the same decimal point location. Over-range or open circuit channel readings are not included in the group calculations and selections.

Parameters

Source 1 is the first channel in the group. Source 2 is the last channel.

The decimal defaults to the rightmost position unless redefined. You can assign units.

Operation

Code	Description
075	Computes the average of a group of channels. Outputs extended precision and displayed data.
076	Selects the maximum value from a group of channels. You can assign Function Code 100 to the channel following the Function Code 076 channel to indicate the address of the channel generating the maximum value. Outputs displayed data.
077	Selects the minimum value from a group of channels. You can assign Function Code 100 to the channel following the Function Code 077 channel to indicate the address of the channel generating the minimum value. Outputs displayed data.
078	Selects the four highest values from a group of channels. The channel assigned Function Code 078 displays the highest value. To display the second, third and/or fourth highest values, assign Function Code 100 to the next three sequentially addressed channels. Outputs displayed data. For example, if you assign Function Code 078 to channel 501, it contains the highest value. To display the second highest value, assign Function Code 100 to Channel 502. To display the third highest value, assign Function Code 100 to Channel 503. To display the fourth highest value, assign Function Code 100 to Channel 504.
079	Selects the four highest values from a group of channels and displays the channel addresses generating these values. Outputs displayed data.

The channel assigned Function Code 079 displays the highest value. To display the address of the channel generating this value and/or the second, third and fourth highest values and their channel addresses, assign Function Code 100 to the next seven sequentially addressed channels.

For example, if you assign Function Code 079 to Channel 501, Channel 501 contains the highest value from the specified group of channels. To display the channel associated with this data, assign Function Code 100 to Channel 502. To display the second highest value and its channel address, assign Function Code 100 to Channels 503 and 504. To display the third highest value and its channel address, assign Function Code 100 to Channels 505 and 506. To display the fourth highest value and its channel address, assign Function Code 100 to Channels 507 and 508.

Channel	501	502	503	504	505	506	507	508
Function	079	100	100	100	100	100	100	100
Displays	Highest Value	Channel Address of Highest Value	2nd Highest Value	Channel Address of 2nd Highest Value	3rd Highest Value	Channel Address of 3rd Highest Value	4th Highest Value	Channel Address of 4th Highest Value

080 Computes the sum of a group of channels. Outputs extended precision and displayed data.

081 Computes the standard deviation of a group of channels. Outputs extended precision and displayed data.

The system uses the following equation to compute the standard deviation (σ).

$$\sigma = \sqrt{\frac{1}{N} \sum_{1}^{N} (x_n - x)^2}$$

N = Number of samples
n = Sample number
x_n = Value of the nth sample
x = Average of all samples

5.13 PAIR FUNCTIONS (082-083)

Functions 082 and 083 select the maximum or minimum values from the displayed data of any two sources. Data from both sources must have the same decimal resolution.

Code	Description
082	Selects the maximum value of the two inputs
083	Selects the minimum value of the two inputs

If one source is open circuit or over-range, the system automatically selects the value of the other source. If both sources are open and/or over-range, an over-range occurs at the channel assigned the pair function.

Parameters

Source 1 is the address of the first input. Source 2 is the address of the second input.

The decimal defaults to the rightmost position unless redefined. The output data is in a displayed format. You can assign units.

Example 1 (compares two measured temperature readings): Select the minimum value from two measured temperature readings and display the value at Channel 301. Channel 101 measures the 1st temperature and Channel 108 measures the 2nd temperature. Assign the following to Channel 301:

Function Code = 083 Source 1 = 101 Source 2 = 108

The system compares the input data from Channel 101 and Channel 108, selects the minimum value and displays it at Channel 301.

Example 2 (compares a measured temperature reading to a temperature constant at a CALC channel): Select the minimum value from two temperatures and display the value at Channel 301. Channel 101 measures the 1st temperature reading. The 2nd temperature is a constant temperature assigned to CALC Channel 044. Assign the following to Channel 301:

Function Code = 083 Source 1 = 101 Source 2 = 044

Assign a constant value to CALC Channel 044. See Section 4.4 for more information.

The system compares the input data from Channel 101 with temperature constant at CALC Channel 044, selects the minimum value and displays it at Channel 301.

Example 3 (compares a measured temperature reading to a temperature assigned to Input 2): Specify the Source 2 address as 000 and assign the temperature constant to Input 2. Select the minimum value from two temperatures and display the value at Channel 301. Channel 101 measures the 1st temperature reading. The 2nd temperature is a constant temperature assigned to Input 2. Assign the following to Channel 301:

Function Code = 083 Source 1 = 101 Source 2 = 000

Assign a constant value to Input 2.

The system compares the input data from Channel 101 with the constant at Input 2, selects the minimum value and displays it at Channel 301.

5.14 MATH FUNCTIONS (084-098)

Functions 084-098 perform a variety of computational routines. Ten operate on a single variable (x_1) and five operate on two variables (x_1 and x_2). Math functions accept extended precision and displayed data.

Code	Operation	Description
084	$x_1 + x_2$	Addition
085	$x_1 - x_2$	Subtraction
086	$x_1 \cdot x_2$	Multiplication
087	x_1/x_2	Division
088	$(x_1)^{x}2$	Base raised to a power
089	$\sqrt{x_1}$	Square root
090	$\log_{10} (x_1)$	Log base 10
091	$\ln (x_1)$	Natural log
092	$e^{(x_1)}$	Exponential
093	Sine (x_1)	Input data in radians
094	Cosine (x_1)	Input data in radians
095	Tangent (x_1)	Input data in radians
096	Arc-Sine (x_1)	Output data in radians
097	Arc-Cosine (x_1)	Output data in radians
098	Arc-Tangent (x_1)	Output data in radians

Parameters

Source 1 is the address of x_1. If the Source 1 address is 000, x_1 is a constant assigned to Input 1. Source 2 (if required by the function code) is the address of x_2. If the Source 2 address is 000, x_2 is a constant assigned to Input 2.

Each math function has a default decimal location. For Function Codes 084 to 089, the decimal defaults to the rightmost position. For Function Codes 090 to 098, the decimal default varies with the function. You can redefine the decimal code and assign units.

Because the result of some math functions, such as $x_1^{(x_2)}$ and $e^{(x_1)}$, may exceed the display capacity quickly, these functions store data in both displayed and extended precision format. Extended precision data is stored internally and can be used as input to other channels that accept extended precision data, even if the display capacity is exceeded.

5.15 POLYNOMIAL TRANSFER FUNCTION (099)

Function 099 evaluates the output (y) of a polynomial equation:

$$y = C_0 + C_1(x_1) + C_2(x_1)^2 + C_3(x_1)^3 + C_4(x_1)^4 \ldots + C_9(x_1)^9$$

Where:

y = output
$C_0, C_1, C_2, C_3, C_4 \ldots C_9$ = user-specified constants
x_1 = input data from Source 1

You can specify as many as 10 terms, but because of the resolution of the displayed data, usually no more than five or six terms are appropriate.

The polynomial transfer function accepts extended precision and displayed data. It outputs extended precision data and displayed and logical data.

Operation

Assign the constant of the zero term to the lowest numbered constant address. Assign constants of successively higher order terms to successively higher numbered constant addresses.

The value of any polynomial constant, C_0, C_1, C_2,...C_9 equals the value assigned to the output constant multiplied by ten to the power specified by the input constant. The input constant must be an integer between -15 and +15. If you do not define the input constant, its value defaults to 0.

$$\text{Polynomial Constant} = (\text{OUTPUT} \times 10^{\text{Input}})$$

For example, to define a polynomial constant of .009852, assign an output constant of 0.9852 and an input constant of -2.

$$.009852 = 0.9852 \times 10^{-2}$$

To end a polynomial function, assign NULL to the input parameter at the constant address immediately following the one that specifies the highest term. In the polynomial equation:

$$y = C_0 + C_1(x_1) + C_2(x_1)^2 + C_3(x_1)^3$$

C_0 is the constant of the zero term. If C_0 is assigned to a Constant Address N, you must assign

C_1 to Constant Address N + 1
C_2 to Constant Address N + 2
C_3 to Constant Address N + 3
NULL to the input parameter at Constant Address N + 4

See Section 4.5 for more information.

Parameters

Source 1 is the channel address of the input data (x_1). Source 2 is the constant address that contains the constant of the zero term.

The decimal defaults to the rightmost position unless redefined.

Example: Assign the polynomial transfer function to Channel 212 in order to evaluate the output (y) in the following polynomial equation:

$$y = 1.0135 + .009852(x_1) + (-.044444)(x_1) + .008337(x_1)$$

Where x_1 is input data from the channel specified by Source 1 (Channel 310) and x_1 is a value between 0.0000 and 1.0000:

$C_0 = 1.0135$	Assign C_0 to Constant Address 30 Output = 1.0135 Input = 00000
$C_1 = .009852$	Assign C_1 to Constant Address 31 Output = 0.9852 Input = -00002
$C_2 = -.044444$	Assign C_2 to Constant Address 32 Output = -4.4444 Input = -00002
$C_3 = .008337$	Assign C_3 to Constant Address 33 Output = 0.8337 Input = -00002
	Constant Address 34 * Input = NULL

* This example does not use the output constant.

Source 1 is 310 (the channel address of input data). Source 2 is 030 (the constant address that contains the constant value of the zero term).

Assign 0.0000 to the decimal code for an output resolution of 0.0001.

5.16 OPTIONAL DATA STORAGE FUNCTION (100)

Function 100 reserves channels so Function Codes 062-063 (interval), 071 (historical buffer), 076-079 (group) and 160 (weighted mixture) can store data. Parameters at the Function 100 channel do not have to be assigned values.

With Function Code 160, you must assign values to Source 1, Source 2, Output 1 and Output 2 at each Function 100 channel. You can also assign limits.

The interval, historical, group or weighted mixture function determines the output decimal location.

5.17 BOOLEAN FUNCTIONS (101-107)

Functions 101-107 apply traditional Boolean operators to two logic bits: A and B.

Logic Bit A results from an AND operation performed on the logic bit specified by Source 1 and the logic bit assigned to Limit 1, Limit Op-code 1. If undefined, the logic bit defaults to true.

Logic Bit B results from an AND operation performed on the logic bit specified by Source 2 and the logic bit assigned to Limit 2, Limit Op-code 1. If undefined, this logic bit defaults to true.

The state of the channel logic bit results from the Boolean operation performed on Logic Bits A and B. Channel output data reflects the state of the channel logic bit. When the logic bit is false, the channel output data is 0.00. When it is true, the channel output data is 1.00 (Figure 5-11).

CALC channels do not accept Function Codes 101-107.

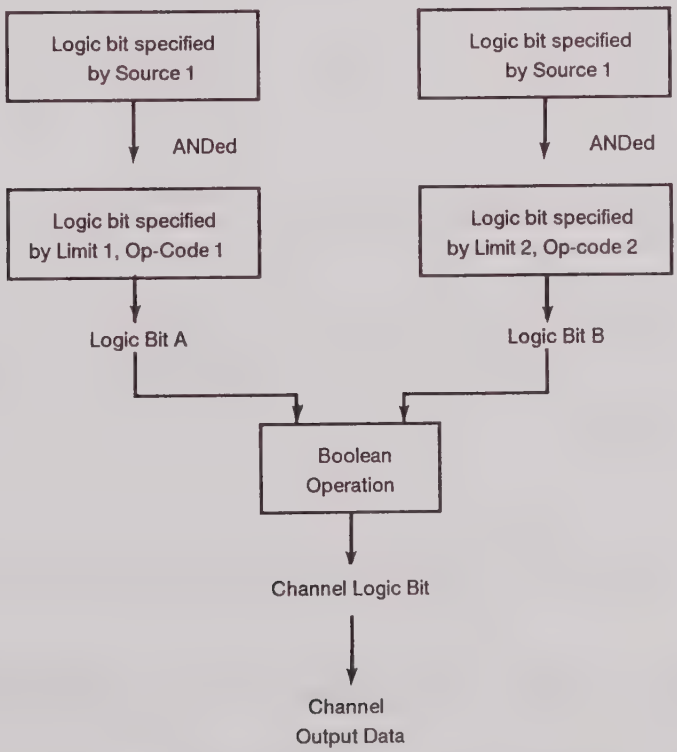


Figure 5-11. Boolean Functions

Table 5-2 on the following page lists Boolean operators.

Table 5-2. Boolean Operators

FUNCTION CODE	Name	Operation	Symbol	Ladder Equivalent
101	AND	$A \bullet B$	A B	A B
102	MIXED AND	$A \bullet \overline{B}$		
103	NOR	$\overline{A+B}$		
104	OR	$A+B$		
105	MIXED OR	$A+\overline{B}$		
106	NAND	$\overline{A \bullet B}$		
107	XOR	$A \bullet \overline{B} + \overline{A} \bullet B$		

Parameters

Source 1 and Source 2 are logic addresses. You can also assign logic addresses to Limit 1, Limit Op-Code 1 and Limit 2, Limit Op-Code 1.

You cannot assign values to Limit 1 and Limit 2, but you can specify limit op-codes for Limit 1 and Limit 2. The system can output a trip message, turn ON the assigned relay and/or turn on the alarm. The op-codes defined for Limit 1 are activated when the channel logic bit is true; the op-codes defined for Limit 2 are activated when the channel logic bit is false.

Operation

Function Code 101 (AND) and Function Code 103 (NOR) can display the state of any logic bit in the system if you assign the address of that logic bit to both Source 1 and Source 2.

AND Function. The channel logic bit is true when the logic bits specified by Source 1 and Source 2 are both true. It is false when the logic bit specified by Source 1 and/or Source 2 is false.

NOR Function. The channel logic bit is true when the logic bits specified by Source 1 and Source 2 are both false. It is false when the logic bit specified by Source 1 and/or Source 2 is true.

Example: To display the state of the logic bit at Logic Address 071 at a channel, assign Function Code 101 to Channel 312 and assign 071 to both Source 1 and Source 2.

When Logic Address 071 is true, the logic bit at Channel 312 is true and 1.00 is displayed. When it is false, the logic bit at Channel 312 is false and 0.00 is displayed.

If we had used the NOR function, the logic bit at Channel 312 would be true when the logic bit at Logic Address 071 was false. It would be false when the logic bit at Logic Address 071 was true.

5.18 FLIP-FLOP FUNCTIONS (108-111)

Functions 108-111 remember the logic state from the previous math scan and remain in that state until the logical inputs change. Logic Bit A (set) and Logic Bit B (clear) determine the state of the channel logic bit. CALC channels do not accept Function Codes 108-111.

Logic Bit A results from an AND operation on the logic bit specified by Source 1 and the logic bit assigned to Limit 1, Limit Op-Code 1. If undefined, it defaults to true.

Logic Bit B results from an AND operation on the logic bit specified by Source 2 and the logic bit assigned to Limit 2, Limit Op-Code 1. If undefined, it defaults to true.

Parameters

Source 1 and Source 2 are logic addresses. You can also assign logic addresses to Limit 1, Limit Op-Code 1 and Limit 2, Limit Op-Code 1.

You cannot assign values to Limit 1 and Limit 2, but you can specify limit op-codes for Limit 1 and Limit 2. The system can output a trip message, turn on the assigned relay and/or turn on the alarm. The op-codes defined for Limit 1 are activated when the channel logic bit is true; the op-codes defined for Limit 2 are activated when the channel logic bit is false.

Operation

These functions differ only in the conditions that set and clear the channel logic bit.

Code	Set	Clear
108	True	True
109	True	False
110	False	True
111	False	False

The system views the states of Logic Bits A and B and determines whether the channel logic bit should be set, cleared to false or remain in the same state as in the previous math scan. See Table 5-3 on the following page.

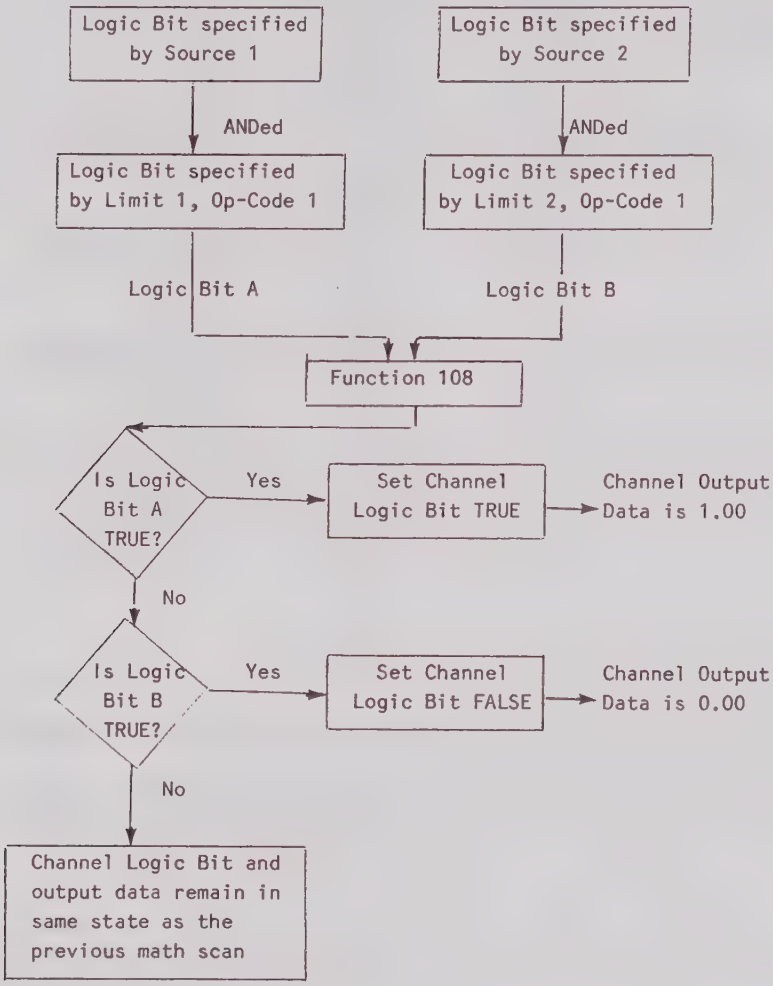
Table 5-3. Flip-Flop Functions

Code		Logic Bit A	Logic Bit B	Channel Logic bit
108	Flip-Flop TT	True	True	True
		True	False	True
		False	True	False
		False	False	Same state as previous math scan
109	Flip-Flop TF	True	True	True
		True	False	True
		False	True	Same state as previous math scan
		False	False	False
110	Flip-Flop FT	True	True	False
		True	False	Same state as previous math scan
		False	False	True
		False	True	True
111	Flip-Flop FF	True	True	Same state as previous math scan
		True	False	False
		False	False	True
		False	True	True

The system sees if the set logic bit (A) is in its required state.

- o If it is, the channel logic bit is set true.
- o If it is not, the system sees if the clear logic bit (B) is in its required state. If it is, the channel logic bit is set false.
- o If neither the set nor clear logic bits is in its required state, the channel logic bit remains in the same state as in the previous math scan.

Example: The following flow chart shows how Function Code 108 operates.



5.19 DATA COMPARE FUNCTIONS (112-113)

Functions 112-113 compare functions compare the displayed data at Source 1 and Source 2 and use the results to determine the state of the logical output data.

Code	Description
112	Channel logic bit is true when the input data from Source 1 is equal to the input data from Source 2
113	Channel logic bit is true when the input data from Source 1 is greater than the input data from Source 2

CALC channels do not accept Function Codes 112-113.

Operation

When the channel logic bit is false, the channel output data is 0.00. When it is true, the channel output data is 1.00.

Parameters

Source 1 and Source 2 are channel addresses.

The decimal point in the Source 1 and Source 2 data must be in the same position.

You can also assign logic addresses to Limit 1, Limit Op-Code 1 and Limit 2, Limit Op-Code 1. You cannot assign values to Limit 1 and Limit 2, but you can specify limit op-codes for Limit 1 and Limit 2. The system can output a trip message, turn on the assigned relay and/or turn on the alarm. The op-codes defined for Limit 1 are activated when the channel logic bit is true; the op-codes defined for Limit 2 are activated when the channel logic bit is false.

Example: Assign Function Code 113 to Channel 514.

Source 1 is Channel Address 312 and Source 2 is Channel Address 512. Assign Function Code 035 (thermocouple) to both addresses.

When the data at Channel Address 312 exceeds the data at Channel Address 512, the logic bit at Channel Address 514 is true. Otherwise, it is false.

5.20 DATA TRANSFER FUNCTIONS (114-115)

Functions 114-115 transfer data from Source 1 based on the state of the logic bit at Source 2.

Code	Description
114	Transfers data when the logic bit specified by Source 2 is true
115	Transfers data when the logic bit specified by Source 2 is false

Assign a data transfer function when you want the system to send a copy of output data from one channel or CALC channel to another. You can use a data transfer function to format reports, to hold or transfer a value that is to be used by another function or to send data to a row of channels for transmission to an Analog Output Module or another Digi 4 Plus.

Parameters

Source 1 is the address of the data to be transferred. If Source 1 is 000, the input data is a constant assigned to Input 1. A manually entered constant simulates a reading (temperature, pressure, flow rate) used in another calculation. For example, to simulate a temperature of 100 C, assign 00100 to Input 1.

Manually entered constants appear in a report. For example, if you are monitoring the specific gravity of a gas outside the Digi 4 Plus system and want to include these readings in a report, assign the value of the specific gravity to Input 1. When a report is output, you can quickly reference the value of the specific gravity by looking at the channel address assigned the data transfer function.

Source 2 is the address of the controlling logic bit.

The decimal defaults to the rightmost position unless redefined. The output data is stored in extended precision format. You can assign units.

Operation

Function Code 114. Input data is transferred continuously as long as the logic bit specified by the Source 2 address is true. Data is not transferred when the logic bit is false. If Source 2 is 000, the system continuously transfers data from the address specified by Source 1 because the logic bit at Logic Address 000 is always true.

Function Code 115. Input data is transferred continuously as long as the logic bit specified by the Source 2 logic address is False. Data is not transferred when the logic bit is true. If Source 2 is 099, the system continuously transfers data from the address specified by Source 1 because the logic bit at Logic Address 099 is always false.

Digi 4 Plus updates channel addresses in ascending order, beginning with CALC Channel Address 001. Assign a data transfer function to a higher addressed channel than the one specified by Source 1 to make sure the most recent channel output is transferred. This allows the system to update the data at the Source 1 channel before updating the channel assigned the data transfer function.

Example 1: Assign Function Code 035 (thermocouple) to Channel 205. You want the system to transfer a temperature reading from Channel 205 to Channel 305 every 5 minutes.

Assign the following to Channel 305:

Function Code = 114
Source 1 = 205 (channel address that contains the temperature readings)
Source 2 = 911 (logic address of System Timer 11 assigned a 5 minute reset)

When System Timer 11 resets, the logic bit at Logic Address 911 turns momentarily true, transferring a temperature reading from Channel 205 to Channel 305.

Example 2: Format a chronological record that displays a rise or drop in barometric pressure over a six-hour time period. The barometric pressure is measured at Channel 101. Do the following to obtain a chronological record of output data:

Assign Function Code 114 to Channels 211, 212, 213, 214, 215 and 216.

Chain the Source 1 channel addresses together. Source 1 is the address of the next sequential channel, except for the last channel (216). Source 1 for Channel 216 is Channel 101, the address of the channel measuring the barometric pressure.

Specify the same logic address for Source 2 (System Timer 905) which was assigned a 1-hour time interval and a reset time of 8:00 A.M. When the logic bit specified by Source 2 makes a false/true transition, data is transferred from one channel to another.

Channel Address	211	212	213	214	215	216
Function Code	114	114	114	114	114	114
Source 1	212	213	214	215	216	101
Source 2	905	905	905	905	905	905

Timer 05 is set to start at 8:00 A.M.

8:00 AM At the start of the 1-hour time interval, the logic bit at Logic Address 905 goes momentarily true and the most current barometric pressure reading is transferred from Channel 101 to Channel 216.

Sample from data report initiated at the start of the 1st 1-hour interval

211	112	213	214	215	216
OVRNG	OVRNG	OVRNG	OVRNG	OVRNG	30.21

9:00 AM Timer 05 resets, the logic bit at Logic Address 905 goes momentarily true, the most current barometric pressure reading is transferred from Channel 101 to Channel 216 and the barometric pressure reading that was previously displayed at Channel 216 is transferred to Channel 215.

Sample from data report initiated at the start of the 2nd 1-hour interval:

211	212	213	214	215	216
OVRNG	OVRNG	OVRNG	OVRNG	30.21	30.15

10:00 AM Timer 05 resets, the logic bit at Logic Address 905 goes momentarily true, the most current barometric pressure reading is transferred from Channel 101 to Channel 216, the barometric pressure reading that was previously displayed at Channel 216 is transferred to Channel 215 and the barometric pressure reading that was previously displayed at Channel 215 is transferred to Channel 214.

Sample from data report initiated at the start of the 3rd 1-hour interval:

211	212	213	214	215	216
OVRNG	OVRNG	OVRNG	30.21	30.15	30.13

1:00 PM Sample from data report initiated at the start of the 6th 1-hour interval:

211	212	213	214	215	216
30.21	30.15	30.13	30.12	30.09	30.10

At the end of each successive hour:

- System Timer 05 resets
- The logic bit at Logic Address 905 goes momentarily true
- The most current barometric pressure reading is transferred from Channel 101 to Channel 216
- The barometric pressure reading previously displayed at Channel 216 is transferred to Channel 215. The reading displayed at Channel 215 is transferred to Channel 214. Each hour another channel receives the reading previously displayed at the next higher addressed channel.

5.21 DATA SELECT FUNCTIONS (116-120)

Functions 116-120 select data from one of two adjacent channels or CALC channels based on the state of a logic bit at a specified logic address.

Codes	Description
116-117	The state of the Source 2 logic bit determines whether input data comes from the channel address specified by Source 1 or from next lower channel address than that specified by Source 1
118-119	The state of the Source 2 logic bit determines whether input data comes from the channel address specified by Source 1 or from next lower channel address than that assigned Function Code 118 or 119
120	The states of the Source 1 and Source 2 logic bits determine which of four user-defined constants is selected for display

Parameters

Function Codes 116 and 117. Source 1 is the address of the second of two consecutive channels or CALC channels. Source 2 is the logic address of the controlling logic bit.

The decimal defaults to the rightmost position unless redefined. You can assign units.

Function Codes 118 and 119. Source 1 is a channel or CALC channel address. Source 2 is the logic address of the controlling logic bit.

The decimal defaults to the rightmost position unless redefined. You can assign units.

Function Code 120. Source 1 and Source 2 are logic addresses.

Input 1, Input 2, Output 1 and Output 2 are assigned constants.

The decimal defaults to the rightmost position unless redefined. You can assign units.

Operation

Function Code 116. When the logic bit at Source 2 is true, input data comes from the Source 1 logic address. When the logic bit at Source 2 is false, input data comes from the next lower address than that specified by Source 1.

Example: Assign Function Code 116 to Channel 405. Source 1 is Channel Address 213 and Source 2 is Logic Address 016.

Input Data Source	Logic Bit State
Channel 213	True
Channel 212	False

Function Code 117 When the logic bit at Source 2 is false, input data comes from the Source 1 logic address. When the logic bit at Source 2 is true, input data comes from the next lower address than that specified by Source 1.

Example: Assign Function Code 117 to Channel 616. Source 1 is CALC Channel Address 032 and Source 2 is Logic Address 052.

Input Data Source	Logic Bit State
CALC Channel 032	False
CALC Channel 031	True

Function Code 118. When the logic bit at Source 2 is true, input data comes from the Source 1 address. When the logic bit at Source 2 is false, input comes from the next lower channel address than the address assigned Function Code 118.

Example: Assign Function Code 118 to Channel 802. Source 1 is Channel Address 103 and Source 2 is Logic Address 104.

Input Data Source	Logic Bit State
Channel 103	True
Channel 801	False

Function Code 119. When the logic bit at Source 2 is false, input data comes from the Source 1 address. When the logic bit at Source 2 is true, input data comes from the next lower address than the address assigned Function Code 119.

Example: Assign Function Code 119 to Channel 709. Source 1 is CALC Channel Address 055 and Source 2 is Logic Address 022.

Input Data Source	Logic Bit State
CALC Channel 055	False
Channel 708	True

Function Code 120. The system outputs one of four constants you define and assign to Input 1, Input 2, Output 1 and Output 2, based on the state of the logic bits specified by Source 1 and Source 2.

Source 1 Bit	Source 2 Bit	Channel Output from
False	False	Input 1
True	False	Input 2
False	True	Output 1
True	True	Output 2

Example: Assign Function Code 120 to Channel 508. The decimal code is 00.000. Source 1 is Logic Address 007. Source 2 is Logic Address 008.

Assign the following constants to the input and output parameters:

Input 1 = 21.653
Input 2 = 14.468
Output 1 = 12.167
Output 2 = 51.169

007 Bit	008 Bit	Channel Output
False	False	21.653
True	False	14.468
False	True	12.167
True	True	51.169

5.22 INTEGER ENCODER FUNCTIONS (121-122)

Functions 121-122 output an integer based on the states of logic bits at specified logic addresses.

Code	Description
121	Outputs an integer (0-3) based on the states of the logic bits at two logic addresses
122	Outputs an integer (0-15) based on the states of the logic bits at four adjacent logic addresses

Parameters

Function Code 121. Source 1 and Source 2 are logic addresses. There is no decimal in the channel output data.

Function Code 122. Source 1 is the first of four adjacent logic addresses. No Source 2 is specified. There is no decimal in the channel output data.

Operation

Function Code 121 is a two-bit integer encoder (0-3). The system outputs one of four integers (0, 1, 2 or 3) based on the state of the logic bits specified by Source 1 and 2.

Source 1 Bit	Source 2 Bit	Channel Output
False	False	0
True	False	1
False	True	2
True	True	3

Example: Assign Function Code 121 to Channel 213. Source 1 is Logic Address 106. Source 2 is Logic Address 206.

Bit 106	Bit 206	Ch. 213 Output
False	False	0
True	False	1
False	True	2
True	True	3

Function Code 122 is a four bit integer encoder (0-15). The system outputs one of 16 integers (0-15) based on the state of the logic bits at four adjacent logic addresses. The Source 1 logic address specifies the first of the four adjacent logic addresses. For example, if Source 1 is 051, the system looks at Logic Addresses 051, 052, 053, 054 to determine the output integer. The following table displays the states of the logic bits at all four logic addresses and the resulting output constant. N is the Source 1 logic address. N + 1 is the the next consecutive logic address; N + 2 and N + 3 are the third and fourth consecutive logic addresses.

Bit N	Bit N+1	Bit N+2	Bit N+3	Ch.Output
False	False	False	False	0
True	False	False	False	1
False	True	False	False	2
True	True	False	False	3
False	False	True	False	4
True	False	True	False	5
False	True	True	False	6
True	True	True	False	7
False	False	False	True	8
True	False	False	True	9
False	True	False	True	10
True	True	False	True	11
False	False	True	True	12
True	False	True	True	13
False	True	True	True	14
True	True	True	True	15

Example: Assign Function Code 122 to Channel 416. Source 1 is Logic Address 052. The system automatically uses the logic bits at Logic Addresses 053, 054 and 055 to determine the output of Channel 416. Using the table as a reference, you can determine the output of Channel 416.

- When the logic bits at Logic Addresses 052, 053, 054 and 055 are all false, the output data at Channel 416 is 0.
- When the logic bits at Logic Addresses 052, 053, 054 and 055 are all true, the output data at Channel 416 is 15.

5.23 CONTROL COUNTER FUNCTION (123)

Function 123 totals the number of times a logic bit makes a false/true transition. CALC channels do not accept Function Code 123.

Each false/true transition of the Source 1 logic bit increments the counter by one. When the logic bit specified by Source 2 is true, the counter resets to zero. While the logic bit is false, the control counter increments until the total equals one less than the value assigned Output 1. On the next false/true transition, the control counter immediately resets to zero and the channel logic bit is set true for a single math scan.

Parameters

Source 1 is the address of the logic bit to be totaled. Source 2 is the address of the logic bit that resets the counter. You can also assign logic addresses to Limit 1, Limit Op-Code 1 and Limit 2, Limit Op-Code 1.

You cannot assign values to Limit 1 and Limit 2, but you can specify limit op-codes for Limit 1 and Limit 2. The system can output a trip message, turn on the assigned relay and/or turn on the alarm. The op-codes defined for Limit 1 are activated when the channel logic bit is true; the op-codes defined for Limit 2 are activated when the channel logic bit is false.

Output 1 is the maximum count value of the control counter (any number up to 65,535). You cannot assign a decimal code.

Operation

Function Code 123 (control counter) and Function Code 060(counter) differ in three ways:

1. The control counter function resets immediately; its value at reset is not held to the next math scan. The counter function does not reset to zero until the math scan immediately following the reset of the counter; the value of the counter function at reset can be used as input data to another channel on the same math scan.

2. You can specify a maximum count value (any number up to 65,535) for the control counter function. The maximum count value for the counter function is fixed at 65,535.

3. You cannot enter limits at a channel assigned the control counter function. You can enter limits at a channel assigned the counter function.

5.24 CONTROL TIMER FUNCTIONS (124-127)

Functions 124-127 keep track of how long a logic bit is true or false.

Codes	Description
124-125	Measure the elapsed time of a true logic bit
126-127	Measure the elapsed time of a false logic bit

Parameters

Source 1 and Source 2 are logic addresses.

Output 1 is the time scaling factor. It defaults to 1. Although the control time is displayed in seconds, the system can also display the control time in minutes or hours. Simply assign the appropriate number of seconds to Output 1. For example, to display the control time in hours, assign 3600 to Output 1.

The decimal defaults to the rightmost position unless redefined. You can redefine it to show 0.1, 0.01, 0.001 or 0.0001 resolution. When time is displayed in seconds, 0.1 is the most accurate resolution.

Operation

When you assign a control time function, the logic bits at Source 1 and Source 2 control its operation. The Source 1 logic bit is the run bit; the Source 2 logic bit is the reset bit. In order to measure elapsed time, the Source 1 logic bit must be in its required run state and the Source 2 logic bit must not be in its required reset state.

Function	Source 1 Bit	Source 2 Bit
124	True	True
125	False	True
126	True	False
127	False	False

For all control timer functions:

- o The reset bit sets the control timer to zero and maintains it at this value for as long as the logic bit specified by Source 2 remains in its reset state.
- o If the elapsed time exceeds the display capacity of the system, an over-range occurs and a control timer is not automatically reset to zero.
- o If a power failure occurs, the control timer maintains its data value. When power returns, it continues to accumulate elapsed time if the run and reset bits are in their required states.
- o A limit value can be assigned. When it exceeded, the channel logic bit can be turned on if specified in Limit Op-Code 2. If you assign the channel logic bit as the address of the reset bit, a control timer can reset itself.

Function Codes 124 and 126 keep track of how long the Source 1 logic bit is true. At the beginning of each math scan, the system checks to see if the Source 1 logic bit is true and the Source 2 logic bit is not in its reset state. If these conditions are met, the system adds the value of the math scan time to the control timer. The output data at the channel address assigned Function Code 124 or 126 represents the total time that the Source 1 logic bit is true.

Function Codes 125 and 127 keep track of how long the Source 1 logic bit is false. At the beginning of each math scan, the system checks to see if the Source 1 logic bit is false and the Source 2 logic bit is not in its reset state. If these conditions are met, the system adds the value of the math scan time to the control timer. The output data at the channel address assigned Function Code 125 or 127 represents the total time that the Source 1 logic is false.

All control timers immediately reset to zero: the value of the timer at reset is not held. Remember that the Elapsed Timer Function Codes 065 and 066 do not reset to zero until the math scan immediately following the false/true transition of the Source 2 logic bit. This allows the value of the elapsed timer at reset to be used as input data to another channel and/or included in a report.

5.25 INDIRECT TRANSFER FUNCTION (128)

Function 128 selects data from one of several addresses. This data can then be used by another function or sent to a peripheral device.

Parameters

Source 1 is the base address. Source 2 is the address of the offset value. The offset value must be positive. The system adds the offset value to the base address specified by Source 1. The function takes its data from the resulting address (001 to 916).

The data addressed by Source 2 is always interpreted as an integer independent of its decimal point. For example, if 3.3 is stored at Source 2, the offset is 33.

The decimal at the Function 128 channel defaults to the rightmost position unless redefined.

Operation

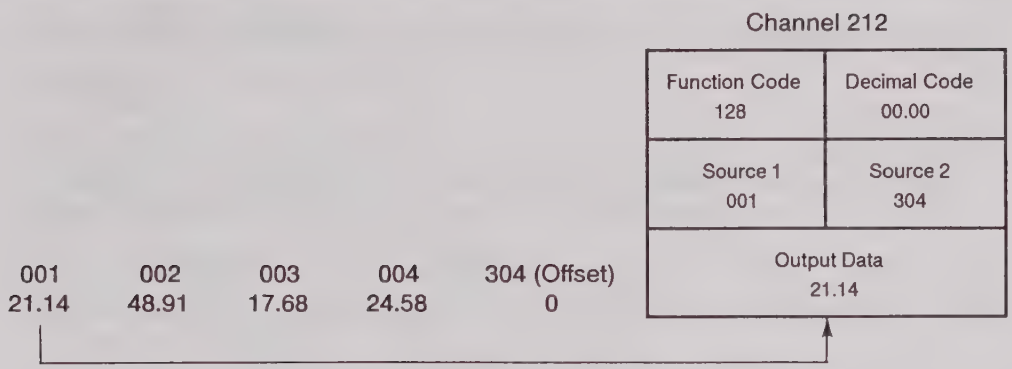
Example 1: An operator is performing a test that requires changing the value of a constant when he changes a thumbwheel setting. He uses the indirect transfer function, which allows the system to select one constant from a pre-defined set. These constants are entered as follows:

CALC Channel	Constant
001	21.14
002	48.91
003	17.68
004	24.58
005	26.10
006	38.91

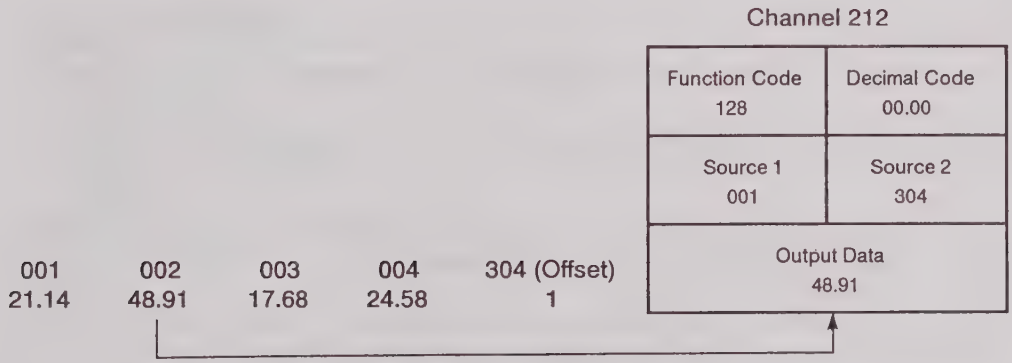
He specifies the constant via a thumb-wheel entry. The thumbwheel is connected directly to 4 status inputs (051-054). An integer encoder function assigned to Channel 304 uses the logic states of the status inputs to output an integer (0-15). The integer reflects the thumbwheel entry.

The operator assigns the indirect transfer function to Channel 212. He specifies Source 1 as 001 because data can be selected from CALC Channel Addresses 001 to 006. He specifies Source 2 as 304 because the integer encoder function assigned to Channel 304 determines the offset value. The figures that follow show how the offset value determines the data selected. When the offset stored at Channel 304 changes, the output data at Channel 212 changes. The output data at Channel 212 can be used as input data by another function or transmitted to a peripheral device.

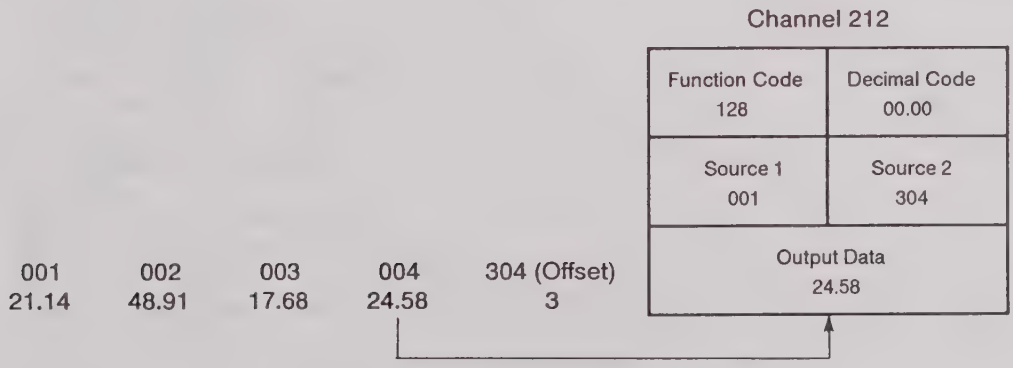
When the offset is 0, data is selected from CALC Channel Address 001.



When the offset is 1, data is selected from CALC Channel Address 002.

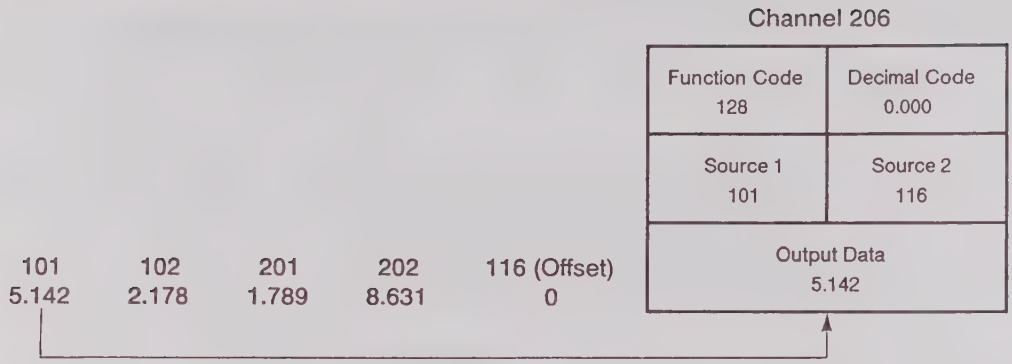


When the offset is 3, data is selected from CALC Channel Address 004.

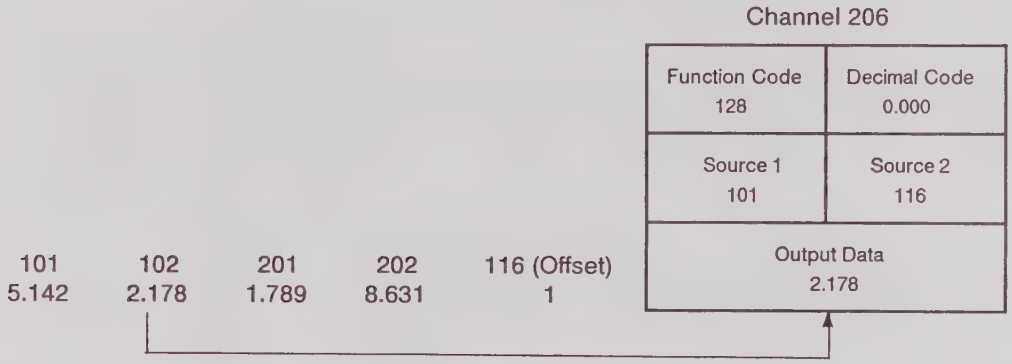


Example 2: The operator assigns the indirect transfer function to Channel 206. Source 1 (base address) is Channel Address 101. Source 2 (address of the offset value) is Channel Address 116. The indirect transfer function can select data from Channel 101, 102, 201 or 202. The figures below show how the offset value determines the data selected. When the off-set stored at Channel 116 changes, the output data at Channel 206 changes. The output data at Channel 206 can be used as input data by another function or transmitted to a peripheral device.

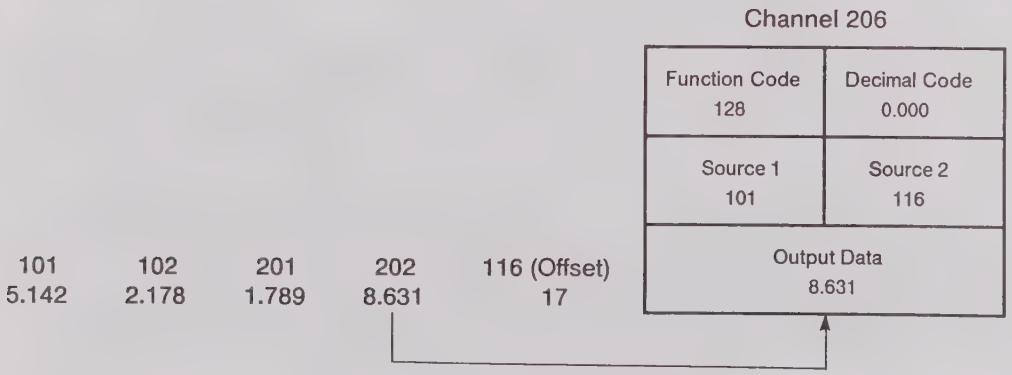
When the offset is 0, data is selected from Channel 101.



When the offset is 1, data is selected from Channel Address 102.



When the offset is 17, data is selected from Channel 202.



5.26 LOGICAL TRANSFER/LOAD DATA VALUE FUNCTION (129)

Function 129 transfers data from another channel or lets you enter data values manually.

Parameters

Source 1 is the channel address of the data to be transferred. Source 2 is a logic address that is compared with the value at Output 2 before data is transferred. If no values are entered at Outputs 1 and 2, data is transferred continuously.

Output 1 is a value of 0 or 1.

- o A value of 0 indicates that data is not transferred from Source 1, but is entered manually at Input 1.
- o A value of 1 indicates that data is transferred from Source 1 based on the value entered at Output 2.

Output 2 is a value of 0 or 1.

- o A value of 0 indicates that data is transferred from Source 1 if the logic bit at Source 2 is false.
- o A value of 1 indicates that data is transferred from Source 1 if the logic bit at Source 2 is true.

The decimal defaults to the rightmost position. You can redefine the decimal code and assign units.

If you have KVIEW, KDIAL or KDAWS software packages, you can change the value of Output 1 and let the operator enter data manually. Or, you can change the value of Output 2 to start and stop the transfer of data.

5.27 APPLICATION FIRMWARE FUNCTIONS (130-133)

Functions 130-133 let you make quick and accurate calculations by assigning a function code and the appropriate parameters to a channel.

Code	Description
130	Computes the percentage of relative humidity in air
131	Computes the volume of liquid in a cylindrical tank
132	Computes the volume of liquid in a spherical tank
133	Computes the lethality rate

5.27.1 Relative Humidity Function (130)

Function 130 computes the percent of relative humidity in air based on the equation:

$$RH = 100 \frac{p(T_w) - K_1 P (1 + K_2 T_w)(T_d - T_w)}{p(T_d)}$$

where: RH = Percent Relative Humidity

T_w = Wet Bulb Temperature (°C)

T_d = Dry Bulb Temperature (°C)

$p(T_w)$ and $p(T_d)$ = Saturation Pressures (in Atmospheres) corresponding to wet bulb and dry bulb temperatures, respectively. These terms are calculated from:

$$p(T_w) = K_3 e^{-\left(\frac{K_4}{T_w + K_5}\right)}$$

$$p(T_d) = K_3 e^{-\left(\frac{K_4}{T_d + K_5}\right)}$$

P = Atmospheric Pressure (Atmospheres)

K_1 = 6.606×10^{-4} ($^{o}C^{-1}$)

K_2 = 1.151×10^{-3} ($^{o}C^{-1}$)

K_3 = 1.39×10^{5} (Atmospheres)

K_4 = 3.929×10^{3} (°C)

K_5 = 2.317×10^{2} (°C)

Reference: ASTM E337.62

Parameters

Source 1 is the channel address of the wet bulb temperature (T_w). Wet bulb temperature is the minimum temperature reached by a wetted thermometer in an airstream. The dry bulb temperature (T_d), ambient temperature, must be at the next higher channel. Temperature values must be in °C. If either T_w or T_d is undefined, an over-range occurs. Source 2 is the channel address of the atmospheric pressure (P). Pressure must be in atmospheres. If the Source 2 address is 000, you can assign a constant that specifies the atmospheric pressure to Input 2. If the value of P is equal to 0.0, the relative humidity is calculated on the basis that T_w is the dewpoint temperature.

The decimal point defaults to the rightmost position. You can redefine the decimal code and assign units.

This function can also compute a relative humidity value using a dew point input instead of a wet bulb temperature. Dew point is the temperature at which water vapors begins to condense. In this case:

- Source 1 is the channel address of the dew point. The dry bulb temperature must be at the next higher channel. Temperature values must be in °C.
- Source 2 is the channel address of the atmospheric pressure (P). When the dew point is used to compute a relative humidity value, P must be zero. Assign 000 to Source 2 and enter a value of zero in the Input 2 parameter.

The decimal defaults to the rightmost position unless redefined. You can assign units.

5.27.2 Cylindrical Tank Volume Function (131)

Function 131 computes the volume of a liquid in a horizontally mounted, cylindrical tank with a circular or elliptical cross section based on the equation:

$$V = V_S \frac{(\arccos(X) - X\sqrt{1-X^2})}{\Pi}$$

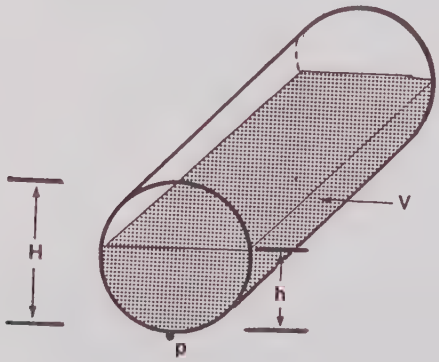
Where:

Arc cosine is expressed in radians
V_S = Volume of full tank in desired units and resolution (scaling factor)

$X = 1 - 2\frac{h}{H}$

h = fill height in tank = $\frac{p}{\rho}$

H = Height of tank in inches
p = Hydrostatic head (pressure) of liquid at bottom of tank in psig
ρ = Value of liquid density in lb/in^3



You can use any other consistent set of units. If either p or H is undefined, an over-range occurs. X is clamped between -1 and +1 for arc-cosine.

Parameters

Source 1 is the channel address of the pressure transducer giving the hydrostatic head of liquid in the tank (p). Source 2 is the channel address that contains the value of the liquid density (ρ). Density can be corrected for temperature on another channel. If the Source 2 address is 000, you can assign the constant that specifies the value of the liquid density to Input 2. If undefined, ρ defaults to one.

Output 1 is the volume in units (gallons, liters) when the tank is completely full (V_S). If V_S is undefined, its default value is one. Output 2 is the height of the tank (H). Express the height in inches consistent with the Source 1 data.

The decimal defaults to the rightmost position unless redefined. You can assign units.

Cylindrical tank volume can also be calculated using a depth transducer that gives the height of the liquid in the tank. In that case, Source 1 is the channel address of the depth transducer; the value of the Source 2 data must be 1 or undefined. If Source 2 is undefined, its default value is one.

5.27.3 Spherical Tank Volume Function (132)

Function 132 computes the volume of a liquid in a spherical tank based on the equation:

$$V = V_s \left(\frac{h}{H}\right)^2 \left[3 - 2\left(\frac{h}{H}\right)\right]$$

Where:

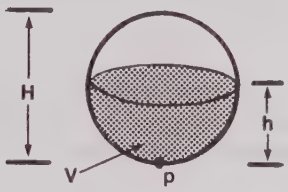
V_s = Volume of full tank in desired units

$h = \frac{p}{\rho}$ = Height (inches) from bottom of sphere to top of segment that intersects it

H = Height of tank (inches)

p = Hydrostatic head (pressure) of liquid at bottom of tank in psig

ρ = Value of liquid density in lb/in^3



Use any consistent set of units as long as the ratio of pressure to density has the same length unit as the diameter. If either pressure (P) or height (H) is undefined, an over-range occurs.

Parameters

Source 1 is the channel address of the pressure transducer giving the hydrostatic head of liquid in the tank (p). Source 2 is the channel address of the value of the liquid density (ρ). (Density can be corrected for temperature on another channel.) If the Source 2 address is 000, you can assign the constant that specifies the value of the liquid density to Input 2. If undefined, ρ defaults to one. ρ is set equal to one if the pressure is measured in units of liquid height.

Output 1 is the volume, in units, when the tank is completely full (V_s). If undefined, V_s defaults to $\Pi D^3/6$. Output 2 is the height of the tank, (H). Express the height in units consistent with the pressure data at Source 1.

The decimal defaults to the rightmost position unless redefined. You can assign units.

You can also calculate the spherical tank volume using a depth transducer that gives the height of the liquid in the tank. In that case, Source 1 is the channel address of the depth transducer; the value of the Source 2 data must be 1 or undefined. If Source 2 is undefined, its default value is one.

5.27.4 Lethality Rate Function (133)

Function 133 computes the lethality rate, L, (sometimes called the equivalent sterilizing time or the incremental value of F) based on the formula:

$$L = 10^{\left(\frac{T-T_b}{Z}\right)}$$

Where:

T = the product temperature

T_b = the base temperature

Z = the temperature difference required to change the D-value by a factor of 10. D-value is the time required to reduce the microbiological population by 90% (one logarithmic cycle) at the particular exposure conditions.

Parameters

Source 1 is the channel address of the product temperature (T). If the Source 1 address is 000, you can assign the constant that specifies the temperature of the product (T) to Input 1. Source 2 is a logic address. When the logic bit at Source 2 is false, the lethality rate equals zero.

Output 1 is the value of Z. Output 2 is the value of T_b.

The decimal code defines the resolution of the output data. If either T, T_b or Z is undefined, an over-range results.

The lethality rate (L) is the ratio of the time required at base temperature to the time required at the measured product temperature to achieve the same total effective reduction of the microbiological population. Integrating the value of L over a given period of time gives the amount of time that would have been required at the base temperature to achieve the same effective sterilization. The integrated value of L is called the F factor, and for steam sterilizing conditions, it is called F_o. To calculate a value of F, use one of the accumulation functions (055 to 058) with the L value as the input data.

For steam sterilization (F_o), T_b = 121.1°C (250.0°F) and Z = 10.0°C (18.0°F) are universally accepted standards. For dry heat sterilization (F_H), T_b = 170.0C (338.0F) and Z = 20.0°C (36.0°F) are proposed standards.

<u>Example</u>: Connect a thermocouple measuring the temperature of the product in a terminal steam sterilization process to a Digi 4 Plus analog scanner and direct it to Channel Address 101 as system input data. The corresponding value of L is computed at Channel Address 201 and the value of F_o is computed at Channel Address 301.

Assign Function Code 133 to Channel Address 201. Assign 101 (the channel address of the product temperature (T) to Source 1. If the value of L is to be set equal to zero at all temperatures below 100.0 C, assign a high limit of 100.0 to Limit 1 at Channel Address 101 and specify the limit op-code to turn on the logic bit when Limit 1 is tripped, but not when the data is invalid. Assign 101 to Source 2 at Channel Address 201; its logic bit will set the value of L to zero when the temperature is below 100.0°C.

Assign 10.0 (the value of Z) to Output 1 at Channel 201 and 121.1 (the value of T_b) to Output 2. Specify the decimal code as 00.000, which permits a value of up to 65.535 to be displayed for L. Values from 0.0001 to 65535 can be displayed for L by assigning the appropriate decimal code.

If the value of F_o is to be printed but not transmitted to a computer when the total resets, assign Function Code 056 (accumulation) to Channel Address 301. Assign 201 (the channel address of L) to Source 1. Source 2 can be the logic address of a status input from an external switch, a logic bit on a calculated process condition or any event desired to reset the total F_o value.

Since F_o is calculated in minutes, set Input 2 equal to 00001. Assign Output 1 and Input 1 values based on the anticipated maximum values and desired resolution of L and F_o.

5.28 CONTROL FIRMWARE FUNCTIONS (140-150)

Digi 4 Plus' interactive control algorithms include standard PID, batch-preload PID, and cascade PID. All are available with error squared. Control firmware functions provide the capability to perform ramp and soak control and adaptive control based on process conditions. The sequencer function continuously inspects the state of the machine or process under control.

Code	Description
140	Performs proportional control/external reset on error
141	Performs proportional control/external reset on error squared
142	Performs standard PID control on error
143	Performs standard PID control on error squared
144	Performs batch-preloaded PID control on error
145	Performs batch-preloaded PID control on error squared
146	Performs cascade PID control on error
147	Performs cascade PID control on error squared
148	Performs track-and-hold (auto-manual)
149	Performs track-or-hold (setpoint)
150	Continuously inspects the state of the machine or process under control

This section contains channel programming formats for each control function. See the Digi 4 PID Control Function Set (Document M4124) for more information on control functions. See A Description of the Digi 4 Sequencer Function (Document M4131) for more information on the sequencer function.

5.28.1 Proportional Control/External Reset Functions (140-141)

Programming formats are the same for Functions 140 and 141. The only difference is that Function 140 performs control on error and Function 141 performs control on error squared.

		FIRST CHANNEL	SECOND CHANNEL
FUNCTION		140	201
CHANNEL OUTPUT		MV	e_n
CHANNEL INPUT DATA LOCATION	SOURCE #1	PB	CV
	SOURCE #2	MR	SP
CHANNEL REGISTER DEFINITION	INPUT #1	VALUE OF PB	VALUE OF CV
	INPUT #2	VALUE OF MR	VALUE OF SP
	OUTPUT #1	OUTPUT CLAMP LOW	INPUT SPAN
	OUTPUT #2	OUTPUT CLAMP HIGH	HIGH CLAMP ON MR
CHANNEL LIMIT FUNCTION	#1	← NORMAL OPERATION →	
	#2	← NORMAL OPERATION →	
LOGIC BIT		← NORMAL OPERATION →	

5.28.2 Standard PID Functions (142-143)

Programming formats are the same for Functions 142 and 143. The only difference is that Function 142 performs control on error and Function 143 performs control on error squared.

		FIRST CHANNEL	SECOND CHANNEL	THIRD CHANNEL	FOURTH CHANNEL
FUNCTION		142	201	202	203
CHANNEL OUTPUT		MANIPULATED VARIABLE (M.V.) (M_n) (% OUTPUT)	LOOP ERROR (S.P.-C.V.) (e_n) (PHYSICAL UNITS)	DERIVATIVE $(\frac{a-1}{a})(D\frac{dx}{dt})$ (Z_n) (PHYSICAL UNITS)	INTEGRAL (LAG) OUTPUT (Y_n) (% OUTPUT)
CHANNEL INPUT DATA LOCATION (Notes 1, 2)	SOURCE #1	AUTO-MANUAL LOGIC BIT	CONTROLLED VARIABLE (C.V.) (Cn)	PROPORTIONAL BAND (PB)	RESET TIME (I)
	SOURCE #2	RESET FEEDBACK (F.B.) (F_n)	SETPOINT (S.P.)	RATE GAIN (D)	INTEGRAL ENABLE LOGIC BIT
CHANNEL REGISTER DEFINITION	INPUT #1	NOT USED	VALUE OF C.V. (PHYSICAL UNITS)	VALUE OF PB (% OF INPUT SPAN)	VALUE OF I (MINUTES)
	INPUT #2	VALUE OF F.B. (% OUTPUT)	SETPOINT VALUE (PHYSICAL UNITS)	VALUE OF D (MINUTES)	NOT USED
	OUTPUT #1	OUTPUT CLAMP LOW (% OUTPUT)	INPUT SPAN (PHYSICAL UNITS)	DERIVATIVE FILTER TIME CONSTANT	LOW CLAMP ON INTEGRAL (LAG) INPUT (% OUTPUT)
	OUTPUT #2	OUTPUT CLAMP HIGH (% OUTPUT)	PMV FALLBACK (% OUTPUT)	PRECLAMP M.V. (P.M.V.) (% OUTPUT)	HIGH CLAMP ON INTEGRAL (LAG) INPUT (% OUTPUT)
CHANNEL LIMIT FUNCTION	#1	← NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT →			
	#2	← NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT →			
LOGIC BIT		← NORMAL OPERATION RELATIVE TO CHANNEL LIMITS →			

5.28.3 Batch-Preload PID Functions (144-145)

Programming formats are the same for Functions 144 and 145. The only difference is that Function 144 performs control on error and Function 145 performs control on error squared.

		FIRST CHANNEL	SECOND CHANNEL	THIRD CHANNEL	FOURTH CHANNEL	FIFTH CHANNEL
FUNCTION		144	201	202	203	204
CHANNEL OUTPUT		MANIPULATED VARIABLE (M.V.) (M_n) (% OUTPUT)	LOOP ERROR (S.P.-C.V.) (e_n) (PHYSICAL UNITS)	DERIVATIVE $(\frac{a-1}{a})(D\frac{dx}{dt})$ (Z_n) (PHYSICAL UNITS)	INTEGRAL (LAG) OUTPUT (Y_n) (% OUTPUT)	INTEGRAL (LAG) INPUT (W_n) (% OUTPUT)
CHANNEL INPUT DATA LOCATION (Notes 1,2)	SOURCE #1	AUTO-MANUAL LOGIC BIT	CONTROLLED VARIABLE (C.V.) (Cn)	PROPORTIONAL BAND (PB)	RESET TIME (I)	LOW PRELOAD LIMIT
	SOURCE #2	RESET FEEDBACK (F.B.) (F_n)	SETPOINT (S.P.)	RATE GAIN (D)	NOT USED	HIGH PRELOAD LIMIT
CHANNEL REGISTER DEFINITION	INPUT #1	NOT USED	VALUE OF C.V. (PHYSICAL UNITS)	VALUE OF PB (% OF INPUT SPAN)	VALUE OF I (MINUTES)	VALUE OF LOW PRELOAD LIMIT (% OUTPUT)
	INPUT #2	VALUE OF F.B. (% OUTPUT)	SETPOINT VALUE (PHYSICAL UNITS)	VALUE OF D (MINUTES)	NOT USED	VALUE OF HIGH PRELOAD LIMIT (% OUTPUT)
	OUTPUT #1	OUTPUT CLAMP LOW (% OUTPUT)	INPUT SPAN (PHYSICAL UNITS)	DERIVATIVE FILTER TIME CONSTANT	NOT USED	LOCAL LOW PRELOAD VALUE (% OUTPUT)
	OUTPUT #2	OUTPUT CLAMP HIGH (% OUTPUT)	PMV FALLBACK (% OUTPUT)	PRECLAMP M.V. (P.M.V.) (% OUTPUT)	NOT USED	LOCAL HIGH PRELOAD VALUE (% OUTPUT)
CHANNEL LIMIT FUNCTION	#1	← NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT →				
	#2	← NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT →				
LOGIC BIT		← NORMAL OPERATION RELATIVE TO CHANNEL LIMITS →				

5.28.4 Cascade PID Functions (146-147)

Programming formats are the same for Functions 146 and 147. The only difference is that Function 146 performs control on error and Function 147 performs control on error squared.

		FIRST CHANNEL	SECOND CHANNEL	THIRD CHANNEL	FOURTH CHANNEL
FUNCTION		146	201	202	203
CHANNEL OUTPUT		MANIPULATED VARIABLE (M.V.) (M_n) (% OUTPUT)	LOOP ERROR (S.P.-C.V.) (e_n) (PHYSICAL UNITS)	DERIVATIVE $(\frac{a-1}{a})(D\frac{dx}{dt})$ (Z_n) (PHYSICAL UNITS)	INTEGRAL (LAG) OUTPUT (Y_n) (% OUTPUT)
CHANNEL INPUT DATA LOCATION (Notes 1, 2)	SOURCE #1	CASCADE-LOCAL LOGIC BIT	CONTROLLED VARIABLE (C.V.) (Cn)	PROPORTIONAL BAND (PB)	RESET TIME (I)
	SOURCE #2	RESET FEEDBACK (F.B.) (F_n)	PRIMARY SETPOINT (SP1)	RATE GAIN (D)	SECONDARY SETPOINT (SP2)
CHANNEL REGISTER DEFINITION	INPUT #1	NOT USED	VALUE OF C.V. (PHYSICAL UNITS)	VALUE OF PB (% OF INPUT SPAN)	VALUE OF I (MINUTES)
	INPUT #2	VALUE OF F.B. (% OUTPUT)	VALUE OF SP1 (PHYSICAL UNITS)	VALUE OF D (MINUTES)	VALUE OF SP2 (% OUTPUT)
	OUTPUT #1	OUTPUT CLAMP LOW (% OUTPUT)	INPUT SPAN (PHYSICAL UNITS)	DERIVATIVE FILTER TIME CONSTANT	LOW CLAMP ON INTEGRAL (LAG) INPUT (% OUTPUT)
	OUTPUT #2	OUTPUT CLAMP HIGH (% OUTPUT)	PMV FALLBACK (% OUTPUT)	PRECLAMP M.V. (P.M.V.) (% OUTPUT)	HIGH CLAMP ON INTEGRAL (LAG) INPUT (% OUTPUT)
CHANNEL LIMIT FUNCTION	#1	← NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT →			
	#2	← NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT →			
LOGIC BIT		← NORMAL OPERATION RELATIVE TO CHANNEL LIMITS →			

5.28.5 Auto-Manual Track-and-Hold Function (148)

Function 148 performs a broad range of track-and-hold operations. It easily interfaces with both PID functions and other track-and-hold functions. Used individually or in combinations, it greatly enhances the range of control strategies available.

CALC channels do not accept Function 148.

		FIRST CHANNEL	SECOND CHANNEL
FUNCTION		148	201
CHANNEL OUTPUT		(AO_n)	(AO_n)
CHANNEL INPUT DATA LOCATION (Notes 1,2)	SOURCE #1	(AI_n)	MANUAL-REQUEST LOGIC BIT
	SOURCE #2	MODE-SELECT AND UP-DOWN SWITCH LOGIC BIT*	AUTO-REQUEST LOGIC BIT
CHANNEL REGISTER DEFINITION	INPUT #1	TRACK-HOLD REGISTER CONTENTS	NOT USED
	INPUT #2	NOT USED	NOT USED
	OUTPUT #1	DELTA VALUE	OUTPUT CLAMP LOW
	OUTPUT #2	NOT USED	OUTPUT CLAMP HIGH
CHANNEL LIMIT FUNCTION	#1	NOT USED	NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT
	#2	NOT USED	NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT
LOGIC BIT		DERIVED A-M STATUS BIT OUTPUT	NORMAL OPERATION RELATIVE TO CHANNEL LIMITS

* FIRST OF TWO LOCATIONS

5.28.6 Auto-Manual Track-and-Hold Function (149)

Function 149 performs a broad range of track-and-hold operations. It easily interfaces with both PID functions and other track-and-hold functions. Used individually or in combinations, it greatly enhances the range of control strategies available. It easily interfaces with both PID functions and with each other.

CALC channels do not accept Function 149.

		FIRST CHANNEL	SECOND CHANNEL
FUNCTION		149	201
CHANNEL OUTPUT		(AO_n)	(AO_n)
CHANNEL INPUT DATA LOCATION (Notes 1,2)	SOURCE #1	(AI_n)	HOLD-TRACK LOGIC BIT
	SOURCE #2	UP-DOWN SWITCH LOGIC BIT (FIRST OF TWO LOCATIONS)	NOT USED
CHANNEL REGISTER DEFINITION	INPUT #1	HOLD-TRACK REGISTER CONTENTS	NOT USED
	INPUT #2	NOT USED	NOT USED
	OUTPUT #1	DELTA VALUE	OUTPUT CLAMP LOW
	OUTPUT #2	NOT USED	OUTPUT CLAMP HIGH
CHANNEL LIMIT FUNCTION	#1	NOT USED	NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT
	#2	NOT USED	NORMAL OPERATION RELATIVE TO CHANNEL OUTPUT
LOGIC BIT		HOLD-TRACK STATUS BIT (TRACKS STATE OF HOLD TRACK LOGIC BIT)	NORMAL OPERATION RELATIVE TO CHANNEL LIMITS

5.28.7 Sequencer Function (150)

Function 150 continuously inspects the state of the machine or process under control. Using a series of user-specified conditions, it sequences the machine or process through its defined states. The sequencer can search for abnormal conditions, make appropriate responses when such conditions are found and generate messages for operator action or information.

CALC channels do not accept Function 150.

When you assign the sequencer to a channel, the system automatically assigns Function Code 211 to the next higher addressed channel if that channel does not already have a non-zero function code.

See A Description of the Digi 4 Sequencer Function (Document M4131) for more information.

FUNCTION		150	211
CHANNEL OUTPUT OUTPUT		STEP	PREV STEP
CHANNEL INPUT DATA LOCATION	SOURCE #1	ADDR OF LOAD LOGIC BIT	OFFSET TO SOURCE 1 at SEQR ADDR
	SOURCE #2	ADDR OF LOAD VALUE	OFFSET TO SOURCE 2 at SEQR ADDR
CHANNEL REGISTER DEFINITION	INPUT #1	DISPLAYS ADDR OF LAST MSG ISSUED	STATUS INPUT OFFSET
	INPUT #2	DISPLAYS LOAD VALUE	STEP OFFSET
	OUTPUT #1	MIN STEP	RELAY OFFSET
	OUTPUT #2	MAX STEP	MESSAGE OFFSET
CHANNEL LIMIT	#1	←NORMAL OPERATION→	
	#2	←NORMAL OPERATION→	
LOGIC BIT		←NORMAL OPERATION→	

5.29 APPLICATION FIRMWARE FUNCTIONS (160-195)

Functions 160-195 let you make quick and accurate calculations by assigning a function code and the required parameters to a channel.

Code	Description
160	Calculates any mixture property by linear weighting
161	Calculates the specific volume of a perfect gas
162	Calculates the specific volume of a natural gas
163, 165	Calculates the specific volume of steam
164, 166	Calculates the enthalpy of steam
167	Calculates specific volume/higher value of natural gas mixtures
170-174	Calculates orifice flow
175	Calculates compressor efficiency
176	Calculates orifice meter correlation
177	Calculates flow nozzle correlation
178	Calculates venturi meter correlation
180-181	Calculates saturation pressure of steam
182-183	Calculates saturation temperature of steam
184-185	Calculates entropy of steam
186-187	Calculates specific volume of water
188-189	Calculates enthalpy of water
190-191	Calculates entropy of water
192-193	Calculates isentropic efficiency of a turbine stage
194-195	Calculates exhaust quality and enthalpy of a turbine stage

The specific volume of a gas is the volume occupied by a unit of mass of that gas. Typical units of specific volume are the number of cubic feet occupied by one pound mass. The density of a gas is the reciprocal of the specific volume, or the mass of that gas contained in a unit volume. Typical units of density are the number of pounds mass contained in one cubic foot.

Most equations of state are expressed in terms of specific volume rather than density, and Function Codes 170-174 (orifice flow equations) are typically expressed in terms of density. Since the specific volume is usually a value that can be displayed to a better resolution in Digi 4 Plus, and since either property can be used in the flow equations (specific volume is the reciprocal of density), Digi 4 Plus firmware is written to give the specific volume of the fluid as the output of the equation of state. Volume rates of flow are divided by the specific volumes to determine the corresponding mass rates of flow.

See Kaye Technical Report 83-3-1, Measuring Flow, Energy, and Compressor Efficiency with a Digi 4 for more information.

5.29.1 Weighted Mixture Function (160)

Function 160 is a general-purpose mixture function that computes any mixture property by a linear weighting of the property by the mol percent of each component.

Parameters

Each channel provides for two mixture components. Source 1 is a channel address that contains the mol percent of one of the two components. Output 1 is assigned the value for that component of the property being computed for the mixture. Source 2 is a channel address that contains the mol percent of the second of the two components. Output 2 is a value that represents the value of the property of that component.

The mixture property, U_m, is computed according to the equation:

$$U_m = \sum_{i=1}^{n} X_i U_i$$

Where:

X_i = The mol percent of component
U_i = The property of component

U_m is the output data at the channel assigned Function Code 160. 00.000 is the default decimal location in the displayed data. The operation of Function Code 160 can be extended to as many channels as desired by assigning Function Code 100 (optional data storage) to successively higher addressed channels. If you use more than one channel, each channel provides for two mixture components where Source 1 and Source 2 are the channel addresses that contain the mol percents of those components. The value of the property of each component is entered as the corresponding output value at each address.

The output data (U_n) at the second channel address (if one exists) is the value of the sum at the first address divided by the sum of the mol fractions.

$$U_n = \frac{\sum_{i=1}^{n} X_i U_i}{\sum_{i=1}^{n} X_i}$$

Data at the second channel address is normalized by the assumption that the sum of all mixture fractions should add to unity and any error is corrected proportionally.

The output data (U_x) at the third channel address (if one exists) is the sum of all mol fractions.

$$U_x = \sum_{i=1}^{n} X_i$$

If more than three channel addresses are used to compute the mixture property, the output data at these channel addresses is zero.

Application of the Weighted Mixture Function

The use of the weighted mixture function is illustrated through an application example that computes the energy content (BTU's) of natural gas mixtures. In applications where the total energy flow is desired, the flow rate of the gas can be determined by one of the flow functions and multiplied by the energy content of the gas.

Energy Content of Natural Gas

The energy content of natural gas can be determined by a calorimeter or computed according to the procedures of Fuel Gas Energy Metering, AGA Report 5, if the gas composition is known. Most gas chromatographs used to determine gas composition also determine the energy content according to AGA Report 5 and provide that value as an output. Therefore, in most applications Digi 4 Plus receives the BTU content of natural gas as an input, and you only have to multiply that value by the appropriate flow rate to determine total energy flow. For those applications where the gas composition is given, but the energy content is not, Function Code 160 can compute the energy content using the constants provided in AGA Report 5.

Digi 4 Plus can compute the energy content of natural gas by any procedure of AGA Report 5, but the preferred method is to use the mass rate of flow determined by the appropriate flow function. Then use the procedure in Section III of AGA Report 5 to determine the value of energy flow. Compute the value to subtract from M_g by applying Function Code 160 to the non-hydrocarbon components using the constant values given on page 28 of AGA Report 5. You can implement any procedures of AGA Report 5 using the appropriate flow and the corresponding constants.

5.29.2 Specific Volume of a Perfect Gas Function (161)

Function 161 computes the specific volume of a perfect gas based on the equation:

$$V = \frac{(R \times CR \times T)}{P}$$

Where:

V = Specific volume
P = Absolute pressure
T = Absolute temperature
R = Constant for a particular gas
(divide the universal gas constant by the molecular weight of the the gas)
CR = Scaling factor

See Kaye Technical Report 83-3-1 for more information.

Parameters

Source 1 is the channel address of the absolute pressure (P). If Source 1 is 000, assign the constant that specifies the absolute pressure to Input 1. Source 2 is the channel address of the absolute temperature (T). If Source 2 is 000, assign the constant that specifies the absolute temperature to Input 2.

Output 1 and Output 2 define the gas constant (R) for a particular gas. Normally the value of R is Output 1 and Output 2 is used as a scaling factor (CR) if one is required to give better resolution. If no value is entered for Output 2, the default is 1.00.

The value of R and the units of pressure, temperature and volume must be a consistent set of absolute values such as those given in Table 5-4.

000.00 is the default decimal. Thus, the maximum value displayed for specific volume is 655.35 unless you redefine the decimal code. You can assign units.

Table 5-4 on the following page gives the value of the universal gas constant for a number of pressure, temperature and volume units. It also gives the corresponding values of specific gas constants for a number of gases. Because the value of the universal gas constant is determined experimentally, there are small differences in the values reported in the literature. There are also small differences in some of the conversion factors employed in various references.

Table 5-4. Universal Gas Constants and Selected Specific Gas Constants

Pressure	Units	lbf/in^2	lbf/ft^2	Atm	Kgf/m^2	$Newt/cm^2$	Atm
Temp	Units	R	R	R	K	K	K
Volume	Units	ft^3/lbm	ft^3/lbm	ft^3/lbm	m^3/Kgm	cm^3/gm	cm^3/gm
Universal Gas Constants	Value	10.7315	1545.34	0.730233	847.970	831.574	82.0700
	Units	$\frac{lbf\text{-}ft^3}{in^2\text{-}mol\text{-}R}$	$\frac{lbf\text{-}ft}{mol\text{-}R}$	$\frac{Atm\text{-}ft^3}{mol\text{-}R}$	$\frac{Kgf\text{-}m}{mol\text{-}K}$	$\frac{Newt\text{-}cm}{mol\text{-}K}$	$\frac{Atm\text{-}cm^3}{mol\text{-}K}$

Specific Gas Constants (Units in Header)

Gas	Molecular Weight	$\frac{lbf\text{-}ft^3}{in^2\text{-}lbm\text{-}R}$	$\frac{lbf\text{-}ft}{lbm\text{-}R}$	$\frac{Atm\text{-}ft^3}{lbm\text{-}R}$	$\frac{Kgf\text{-}m}{Kgm\text{-}K}$	$\frac{Newt\text{-}cm}{gm\text{-}K}$	$\frac{Atm\text{-}cm^3}{gm\text{-}K}$
Air	28.9644	0.370507	53.3531	0.025211	4 29.2763	28.7102	2.83348
NH_3	17.0306	0.630130	90.7390	0.042777	49.7910	48.8282	4.81897
CO	28.0106	0.383123	55.1698	0.026070	30.2732	29.6878	2.92996
CO_2	44.0100	0.243842	35.1134	0.016592	19.2677	18.8951	1.86480
H_2	2.0159	5.3234	766.58	0.36224	420.64	412.51	40.7113
N_2	28.0134	0.38310	55.1643	0.026067	30.2702	29.6849	2.92967
O_2	31.9988	0.33537	48.2937	0.02282	26.5001	25.9877	2.56478
SO_2	64.07	0.16750	24.1196	0.011397	13.2350	12.9791	1.28094
Methane	16.0430	0.66892	96.3248	0.045517	52.8561	51.8341	5.11563
Ethane	30.0701	0.35688	51.3912	0.024284	28.1998	27.6545	2.72929
Propane	44.0972	0.24336	35.0439	0.016560	19.2296	18.8578	1.86112
Butane	58.1243	0.18463	26.5868	0.012563	14.5889	14.3068	1.41197
Pentane	72.1513	0.14814	21.4180	0.010121	11.7527	11.5254	1.13747
Hexane	86.1782	0.12453	17.9319	0.008474	9.8397	9.6495	0.95233
Ethylene	28.0542	0.38253	55.0841	0.026029	30.2261	29.6417	2.92541

The reference generally considered to have the most accurate standard values is the CRC Handbook of Chemistry and Physics (Boca Raton, FL: CRC Press, 1982, 63rd edition). The value of the universal gas constant given there and the conversion factors required to convert it to other units are given below:

R = 8.31441 Joules/gm-mol-K
1 Joule = 10.1988 cm-Kgf
1 Joule = 100.016 cm-Newton
1 Joule = 0.737562 Ft-lbf
1 Newton = 100000 Dynes
1 Newton = 0.1019716 Kgf
1 lbm = 453.59237 gm
1 atm = 10.1325 $Newton/cm^2$
1 atm = 14.69595 lbf/in^2
1 atm = 2116.217 lbf/Ft^2
1 inch H_2O (60F) = 0.036093 lbf/in^2
1 inch H_2O (68F) = 0.036063 lbf/in^2

All real gases deviate to some degree from the perfect gas relation, and the simplest modified relation is given by the equation:

$$V = \frac{ZRT}{P}$$

Where the compressibility factor (Z) is the ratio of the actual specific volume to the specific volume calculated by the perfect gas relation.

It is often possible to develop relatively simple relations for the Z factor of a gas over the range of pressure and temperature encountered. Using the Digi 4 Plus polynomial and math functions to calculate the value of Z as a function of pressure and temperature, and combining that value with the preceding equation usually determines the specific volume of the gas to a level of accuracy better than the accuracy of transducers used to measure pressure and temperature.

5.28.3 Specific Volume of Natural Gas Function (162)

Function 162 computes the specific volume of a natural gas based on the equation:

$$V = 0.37010 \quad C_v \frac{TZ}{PG}$$

Where:

V = Specific volume in cubic feet per pound of mass (Ft/lbm)
C_v = Conversion factor (For specific volume in units other than Ft/lbm.)
T = Temperature in Degrees R. (T = t + 459.7)
Z = Compressibility factor
P = Pressure in psia
G = Specific gravity

See Kaye Technical Report 83-3-1 for more information on this function.

Function Code 162 requires three adjacent channel addresses to compute the specific volume of natural gas using the preceding equation and the NX-19 procedures to determine the value of Z. The value of the supercompressibility factor ($F_{p)}v$, determined by NX-19, is related to Z by the equation:

$$F_{pv} = \frac{1}{\sqrt{Z}}$$

When you assign this function to a channel, the system automatically assigns Function Codes 201 and 202 to the next two higher addressed channels. Digi 4 Plus will not accept Function Code 162 at a channel unless the next two higher addressed channels have Function Code 000.

The displayed output data at:

- The first channel is specific volume (V) in Ft^3/lbm.
- The second channel is the ratio of the specific volume to the specific volume at a specified base condition (V/V_b). When the mass flow rate is expressed as the equivalent volume flow at base (standard) conditions, the volume rate of flow is divided by the ratio of the specific volume at flowing condition to the specific volume at base conditions.
- The third channel is the supercompressibility factor (F_{pv}), which is the square root of the reciprocal of the compressibility factor (Z).

The default decimal locations in the displayed data are:

- 00.000 for the specific volume (V).
- 0.0000 for both the ratio of specific volume to that at a specified base condition (V/V_b) and the supercompressibility factor (F_{pv}).

You can redefine the decimal code.

Parameters

At the **first** channel address:

Source 1 is the channel address that contains the pressure (P) in psia. Source 2 is the channel address that contains the temperature (t) in ^{o}F.

Output 1 is the value of the base pressure, in psia. Output 2 is the value of the base temperature in ^{o}F.

At the **second** channel address:

Source 1[4] is the channel address that contains the specific gravity (G). Source 2[4] is the channel address that contains the conversion factor, C_v. If C_v is undefined, its default is one.

Output 1 is the specific gravity at base conditions. Since AGA-3 assumes by implication that the base specific gravity is always equal to the flowing specific gravity, the base specific gravity is set equal to the flowing specific gravity (G) if no value is enabled for Output 1. Output 2 is not used. (Technical Report 83-3-1)

At the **third** channel address:

Source 1[4] is the channel address that contains the mol percent of CO_2. Source 2[4] is the channel address that contains the mol percent of N_2. If the mol percent of either CO_2 or N_2 is undefined, its default is zero.)

Output 1 is the base value of mol percent CO_2. Output 2 is the base value of mol percent N_2. If the base value of mol percent for either CO_2 or N_2 is undefined, its default is zero.

---

4. You can enter the specific gravity (G), conversion factor (C_v), mol percent of COH2Y and the mol percent of N_2 as constants in the appropriate input parameter if the corresponding source is 000.

5.29.4 Specific Volume of Steam Functions (163 and 165)

Functions 163 and 165 calculate the specific volume in Ft^3/lbm using equations in the ASME steam tables.

Code	Description
163	Calculates the specific volume of steam for a temperature input in °F
165	Calculates the specific volume of steam for a temperature input in °C

Parameters

Source 1 is the channel address of the pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the channel address of the temperature. Input temperatures must be above the saturation line. (See ASME steam tables.) If Source 2 is 000, Input can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 can be used to convert the output data from Ft^3/lbm to other units.

The decimal location is 0.000 unless redefined. You can assign units.

5.29.5 Enthalpy of Steam Functions (164 and 166)

Functions 164 and 166 calculate the enthalpy of steam.

Code	Description
164	Calculates the enthalpy of steam for a temperature input in °F
166	Calculates the enthalpy of steam for a temperature input in °C

Parameters

Source 1 is the channel address of the pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the channel address of the temperature. Input temperatures must be above the saturation line. (See ASME steam tables.) If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 can be used to convert the output data from BTU/lbm to other units.

The decimal location is 00000. unless redefined. You can assign units.

5.29.6 Specific Volume/Higher Value of Natural Gas Mixtures Function (167)

Function 167 calculates the specific volume of a natural gas based on AGA-8. It also computes the compressibility factor, the mass density, the molecular weight of the mixture and the sum of the portions of the component gases.

Inputs are the measured pressure and temperature of the gases and the mol percents or mol fractions of up to 20 component gases.

This function code requires 11 adjacent channel addresses. When you assign it, the system automatically assigns Function Codes 201 through 210 to the next 10 channels. Function Code 167 is rejected if non-zero function codes are already assigned at these channels.

Parameters

At the **first** channel address:

Source 1 is the address of the pressure. Source 2 is the address of the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 (optional) is a constant (0-3) that specifies the temperature units. 0 = F, 1 = R, 2 = C, 3 = K. If undefined, it defaults to ^{o}F.

The output data is the specific volume (V) in cubic feet per pound mass unless converted to other units in the second channel.

The decimal location is 0.000 unless redefined. You can assign units.

At the **second** through **eleventh** channel addresses:

These channels specify the mol percent or mol fraction of up to 20 component gases (Table 5-5 on the following page). Enter all components in consistent units. The sum of the components should equal 1 if you use mol fractions, or 100 if you use mol percent. If the sum does not equal 1 or 100, the function distributes the difference proportionately among the components.

To calculate the mol percent, enter the address of the channel performing the calculation in the appropriate Source 1 or Source 2. If you want to use a constant for the mol percent, leave the default (000) at the source field and enter the constant in the appropriate Input 1 or Input 2.

The decimal location for these channels is 0. unless redefined. You can change the resolution of the output rate.

Table 5-5. Function Code 167 Channel Assignments

Channel	Source 1	Source 2	Out 1	Out Data	Decimal
2nd	%nitrogen	%carbon dioxide	KOUT	Z	0.
3rd	%hydrogen sulphide	%water		D	0.
4th	%helium	%methane		d	0.
5th	%ethane	%propane		MV	0.
6th	%n-butane	%i-butane		sum	0.
7th	%n-pentane	%i-pentane		B	0.
8th	%n-hexane	%n-heptane			0.
9th	%n-octane	%n-nonane			0.
10th	%n-decane	%oxygen			0.
11th	%carbon monoxide	%hydrogen			0.

At the **second** channel address:

Source 1 is the percentage of nitrogen. Source 2 is the percentage of hydrogen.

Output 1 (KOUT) is a constant that can convert the mass density (D) and the specific volume (V) to units other than pounds per cubic foot and cubic feet per pound.

The output data (Z) is the compressibility factor, which is a ratio of the actual specific volume to the ideal gas specific volume at the same temperature, pressure and molecular weight.

At the **third** channel address:

Source 1 is the percentage of hydrogen sulphide. Source 2 is the percentage of water.

The output data is the density (D) in pounds per cubic foot.

At the **fourth** channel address:

Source 1 is the percentage of helium. Source 2 is the percentage of methane.

The output data is is the molar density (d) in pounds per cubic foot.

At the **fifth** channel address:

Source 1 is the percentage of ethane. Source 2 is the percentage of propane.

The output data is the molecular weight (MW) of the mixture in pounds mass per mol.

At the **sixth** channel address:

Source 1 is the percentage of n-butane. Source 2 is the percentage of i-butane.

The output data is the total of the gas components (sum). If the sum does not equal 1 (mol fraction) or 100 (mol percent), the difference is distributed proportionately among the components.

At the **seventh** channel address:

Source 1 is the percentage of n-pentane. Source 2 is the percxentage of i-pentane.

The output data is the second viral coeeficient (B).

At the **eighth** channel address:

Source 1 is the percentage of n-hexane. Source 2 is the percxentage of n-heptane.

At the **ninth** channel address:

Source 1 is the percentage of n-octane. Source 2 is the percxentage of n-nonane.

At the **tenth** channel address:

Source 1 is the percentage of n-decane. Source 2 is the percxentage of oxygen.

At the **eleventh** channel address:

Source 1 is the percentage of carbon monoxide. Source 2 is the percxentage of hydrogen.

Channels 8 through 11 do not display output data; the word over-range is displayed in reports.

5.29.7 Orifice Flow Functions (170-174)

There are a number of correlations of fluid flow through an orifice meter. Digi 4 Plus has five functions that can calculate orifice flow as a function of the pressure drop across the orifice and the fluid properties.

Function 170 calculates orifice meter flow when operating conditions do not vary significantly.

Functions 171-174 provide more accurate determination of the orifice meter flow by accounting for the effects of Reynold's number, post contraction and expansion of the fluid stream and the thermal expansion of the orifice plate.

Simple Orifice Flow Function (170)

Function 170 approximates the mass flow through an orifice meter using the equation:

$$Q_m = C_s S \sqrt{\frac{\Delta P}{\sqrt{V}}}$$

Where:

Q_m = Mass flow of a fluid
ΔP = Pressure drop across the orifice
V = Specific volume of the fluid
C_s = Constant calculated to provide desired value of flow rate for given values of pressure drop and specific volume
S = Scale factor

See Kaye Technical Report 83-3-1 for for more information.

Parameters

Source 1 is the channel address of the pressure drop value across the orifice. If Source 1 is 000, you can assign the constant address of the pressure drop value to Input 1. Source 2 is the channel address of the specific volume of the fluid. (Calculate this value using Function Code 161, 162 or 163.) If the Source 2 is 000, you can assign the constant address of the specific volume to Input 2.

Output 1 is C_s, the constant calculated to provide the desired value for given values of pressure drop and specific volume. Output 2 is a scaling factor (S) for the Input 1 constant. If no value is entered for Output 2, it defaults to 1.00.

The decimal location is 00000. unless redefined. You can assign units.

Example: An orifice meter measures the flow rate of natural gas and is proofed at a pressure of 15.0 psia and a temperature of 75.0F (534.7R) with gas that has a specific gravity of 0.600. The supercompressibility function equals 1.000, so the specific volume, calculated from Function Code 162, is 21.988 Ft/lbm. If the flow rate is known to be 45100 SCFH when the pressure drop is 97.8 inches water, the value of C_s is 21384.

Orifice Flow Functions (171-174)

These functions operate in the same way, but use different correlations of certain parameters. Assign the function suited to your installation.

Code	Description
171	For flange tap installations where the flowing pressure is measured upstream of the orifice plate
172	For flange tap installations where the flowing pressure is measured downstream of the orifice plate
173	For pipe tap installations where the flowing pressure is measured upstream of the orifice plate
174	For pipe tap installations where the flowing pressure is measured downstream of the orifice plate

See Kaye Technical Report 83-3-1 for more information.

The functions require three adjacent channels. When you assign an orifice flow function to a channel, the system automatically assigns Function Codes 201 and 202 to the next two higher addressed channels. Digi 4 Plus rejects Function Codes 171, 172, 173 or 174 if the next two higher addressed channels have a non-zero function code.

The displayed data at:

- The first channel is the volume flow at flowing conditions (Q_v) in thousands of cubic feet per hour (MCFH).
- The second channel is the volume flow at base conditions (Q_b) in thousands of standard cubic feet per hour (MSCFH).
- The third channel is the mass flow (Q_m) in thousands of pounds mass per hour (MPPH).

The default decimal location at each channel is 00000. You can redefine the decimal code.

Parameters

At the **first** channel address:

Source 1[5] is the address of the pressure drop across the orifice in inches of water (at 68.0°F with g = 32.174 Ft-lbf/lbm-sec). Source 2 is the address of the specific volume of the fluid at flowing conditions, Ft/lbm.

---

5. Since most references and most pressure transducer manufacturers convert pressure into an equivalent height of water using the density at 68°F and a gravitational constant of 32.174 Ft-lbm/lbf-sec^2; and since the scaling functions of Digi 4 Plus can be used to convert the pressure values to any desired units, the orifice flow equations of Digi 4 Plus assume the differential pressure is expressed in inches of water at 68°F with a gravitational constant of 32.174 Ft-lbm/lbf-sec^2.

If the units of differential pressure are inches of water at 60°F and the gravitational constant is 32.17 Ft-lbm/lbf-sec^2 (per AGA-3), the pressure value can be scaled by a linear transfer function whose Input 1 and Output 1 values are both 00.000 with Input 2 equal to 62.362 and Output 2 equal to 62.316.

Output 1 is the orifice diameter in inches. Output 2 is the inside pipe diameter in inches.

At the **second** channel address:

Source 1 is the address of the ratio of the specific volume of the fluid at flowing conditions to the specific volume of the fluid at base conditions, V/V_b. Source 2 is the address of the viscosity of the fluid in units which become centipoise when multiplied by the value assigned Output 2.

Output 1 is a constant that used as a units conversion factor, or a meter proof factor. Output 2 is the value of the viscosity multiplier. If Output 1 and Output 2 are undefined, they default to one.

At the **third** channel address:

Source 1 is the address of the flowing pressure in psia. Source 2 is the address of the flowing temperature in ^{o}F.

Output 1 is a value equal to 10^5 times the thermal expansion coefficient of the material of the orifice plate in in/in/^{o}F. If Output 1 is undefined, it defaults to zero. Output 2 is the specific heat ratio of the flowing gas. If Output 2 is undefined, it defaults to (1.3).

5.29.8 Compressor Efficiency Function (175)

Function 175 computes compressor efficiency based on the Benedict-Webb-Rubin equation of state.

See Kaye Technical Report 83-3-1 for more information.

Digi 4 Plus has firmware to compute the isentropic efficiency of a natural gas compression process based on the Benedict-Webb-Rubin equation of state and the procedures of the AGA Mark 2 Program. Function Code 175 computes the isentropic compression efficiency; the inlet density, enthalpy and entropy; the exit density, enthalpy and entropy; the temperature and enthalpy of the isentropic exit state based on the measured inlet pressure and temperature; the measured exit pressure and temperature; and the mol fractions of up to ten component gases.

Digi 4 Plus math functions can compute other parameters in combination with those computed by Function Code 175. For example, an overall efficiency can be computed by multiplying the isentropic efficiency by a mechanical efficiency. The flow can be calculated using one of the orifice meter functions and total power can be computed by multiplying the flow by the actual work done on the gas. Operating parameters such as the pressure ratio and temperature ratio can be computed using the divide function. Actual density of the mixture can be computed by multiplying the molal density by the molecular weight. The isentropic efficiency function provides a tool to be used with other Digi 4 Plus features for analyzing and optimizing operation of a compressor.

Function Code 175 requires ten adjacent channel addresses. When you assign this function code to a channel, the system automatically assigns Function Codes 201, 202, 203, 204, 205, 206, 207, 208 and 209 to the next nine higher addressed channels. Digi 4 Plus will not accept Function Code 175 at a channel unless the next nine higher addressed channels have Function Code 000.

Parameters

Specify the channel address that contains the values of the measured inlet pressure and temperature, the measured exit pressure and temperature, the base pressure and temperature, the specific volume of air at base conditions and the mol fractions of up to ten component gases.

Table 5-6 on the following page lists specific channel assignments and the output data at each channel address. The output data is function, not source, related. Digi 4 Plus calculates the output data displayed at each channel address based on all input source data, not just the input source data at the channel address where it is displayed.

Table 5-6. Function Code 175 Summary

Channel Address	Function Code	Source 1 Data	Source 2 Data	Channel Output Data[6]
nnn	175	Inlet press., psia	Mol % of CO_2	Value of isentropic compression efficiency
nnn+1	201	Inlet temp., °F	Mol % of nitrogen	Work done on each pound of gas, Ft-lbf/lbm
nnn+2	202	Exit press., psia	Mol % of methane	Molecular weight of mixture, lbm/lb-mol
nnn+3	203	Exit temp., °F	Mol % of Ethane	Molal density of inlet state, Ft^3/lb-mol
nnn+4	204	Base press., psia	Mol % of propane	Compressibility factor of inlet state
nnn+5	205	Base temp., °F	Mol % of i-Butane	Molal density of exit state, state, Ft^3/lb-mol
nnn+6	206	Specific vol. of air at base conditions, Ft^3/lbm	Mol % of n-Butane	Compressibility factor of exit state
nnn+7	207	Specific heat constant pressure, BTU/lb-Mol/°R[7]	Mol % of i-Pentane	Molal density of base state, at Ft^3/lb-mol
nnn+8	208		Mol % of n-Pentane	Compressibility factor of base state
nnn+9	209		Mol % of n-Hexane	Specific gravity of mixture at base state

6. The default decimal location is 0000.0 for nnn and 00000. for nnn+1 through nnn+9. You can redefine the decimal code for all channels.

7. The default value is 8.0 BTU/lb-mol/°R.

5.29.9 Orifice Flow/Upstream Pressure Tap Function (176)

Function 176 measures the orifice flow based on the ASME-MFS-3M-1985 standard using upstream pressure tap.

This function occupies four adjacent channels. When you assign it to a channel, the system automatically assigns Function Codes 201, 202 and 203 to the next three higher addressed channels. Digi 4 Plus rejects Function Code 176 if the next three higher addressed channels have a non-zero function code.

The output data at:

- The first channel is the volume flow at flowing conditions (Q_v) in thousands of cubic feet per hour (MCFH).
- The second channel is the volume flow at base conditions (Q_b) in thousands of standard cubic feet per hour (MSCFH).
- The third channel is the mass flow (Q_m) in thousands of pounds mass per hour (MPPH).
- The fourth channel is the product of the discharge coefficient and the expansion coefficient (C_y); that is, deviation of the flow from the base flow.

The decimal location is 0. at all channels unless redefined. You can assign units.

Parameters

At the **first** channel address:

Source 1[8] is the address of the pressure drop across the orifice in inches of water (at 68.0°F with g = 32.174 Ft-lbf/lbm-sec^2). Source 2 is the address of the specific volume of fluid at flowing conditions in Ft^3/lbm.

Output 1 is the orifice diameter in inches. Output 2 is the inside pipe diameter in inches.

At the **second** channel address:

Source 1 is the address of the ratio of the specific volume of the fluid at flowing conditions to the specific volume of the fluid at base conditions (V/V_b). Source 2 is the address of the viscosity of the fluid in units that become centipose when multiplied by the value in Output 2.

---

8. Since most references and most pressure transducer manufacturers convert pressure into an equivalent height of water using the density at 68.0°F and a gravitational constant of 32.174 Ft-lbm/lbf-sec^2 and, since the scaling functions of the Digi 4 Plus can be used to convert the pressure values to any desired units, the orifice flow equations of Digi 4 Plus assume the differential pressure is expressed in inches of water at 68F with a gravitational constant of 32.174 Ft-lbm/lbf-sec^2.

If the units of differential pressure are inches of water at 60.0°F and the gravitational constant is 32.17 Ft-lbm/lbf-sec^2 (per AGA-3), the pressure value can be scaled by a linear scaling transfer function whose Input 1 and Input 2 values are both 00.000 with Input 2 equal to 62.362 and Output 2 equal to 62.316.

At the **third** channel address:

Source 1 is the address of the flowing pressure in psia. Source 2 is the address of the flowing temperature in °F.

Output 1 is the coefficient of the thermal expansion of the material of the orifice plate in 10^5 inches in °F. If undefined, it defaults to 0. Output 2 is the specific heat ratio of the flowing gas. If undefined, it defaults to 1.3.

At the **fourth** channel address:

Source 1 is the temperature in °F at which the orifice diameter and pipe diameter were measured.

Output 1 is the coefficient of thermal expansion of the pipe in 10^5 inches/inch/°F. Output 2 is a constant that specifies the type installation and orifice (Table 5-7).

Table 5-7. Output 2 Values - Function Code 176

Constant	Installation and Orifice
0	Incompressible fluid in a flange-tap orifice
1	Incompressible fluid in a corner-tap orifice
2	Incompressible fluid in a D and D/2 orifice
3	Upstream line pressure measurement in a flange-tap orifice
4	Upstream line pressure measurement in a corner-tap orifice
5	Upstream line pressure measurement in a D and D/2 tap orifice
6	Downstream line pressure measurement in a flange-tap orifice
7	Downstream line pressure measurement in a corner-tap orifice
8	Downstream line pressure measurement in a D and D/2 tap orifice

5.29.10 Flow Nozzle Function (177)

Function 177 measures flow nozzle correlation based on the ASME-MFS-3M-1985 standard.

This function occupies four adjacent channels. When you assign it to a channel, the system automatically assigns Function Codes 201, 202 and 203 to the next three higher addressed channels. Digi 4 Plus rejects Function Code 177 if the next three higher addressed channels have a non-zero function code.

The output data at:

- The first channel is the volume flow at flowing conditions (Q_v) in thousands of cubic feet per hour (MCFH).
- The second channel is the volume flow at base conditions (Q_b) in thousands of standard cubic feet per hour (MSCFH).
- The third channel is the mass flow (Q_m) in thousands of pounds mass per hour (MPPH).
- The fourth channel is the product of the discharge coefficient and the expansion coefficient (C_y); that is, deviation of the flow from the base flow.

The decimal location is 0. at all channels unless redefined. You can assign units.

Parameters

At the **first** channel address:

Source 1[9] is the address of the pressure drop across the nozzle in inches of water (at 68.0°F with g = 32.174 Ft-lbf/lbm-sec^2). Source 2 is the address of the specific volume of the fluid at flowing conditions in Ft^3/lbm.

Output 1 is the nozzle diameter in inches. Output 2 is the inside pipe diameter in inches.

At the **second** channel address:

Source 1 is the address of the ratio of the specific volume of the fluid at flowing conditions to the specific volume of the fluid at base conditions (V/V_b). Source 2 is the address of the viscosity of the fluid in units that become centipoise when multiplied by the value in Output 2.

---

9. Since most references and most pressure transducer manufacturers convert pressure into an equivalent height of water using the density at 68.0°F and a gravitational constant of 32.174 Ft-lbm/lbf-sec^2 and, since the scaling functions of the Digi 4 Plus can be used to convert the pressure values to any desired units, the nozzle flow equations of Digi 4 Plus assume the differential pressure is expressed in inches of water at 68F with a gravitational constant of 32.174 Ft-lbm/lbf-sec^2.

If the units of differential pressure are inches of water at 60.0°F and the gravitational constant is 32.17 Ft-lbm/lbf-sec^2 (per AGA-3), the pressure value can be scaled by a linear scaling transfer function whose Input 1 and Input 2 values are both 00.000 with Input 2 equal to 62.362 and Output 2 equal to 62.316.

Output 1 is a constant that is used as a units conversion factor or a meter proof factor. Output 2 is the value of the viscosity multiplier. If undefined, they default to 1.

At the **third** channel address:

Source 1 is the address of the flowing pressure in psia. Source 2 is the address of the flowing temperature in ^{o}F.

Output 1 is the coefficient of the thermal expansion of the material of the nozzle in 10^5 inches/inch/^{o}F. If undefined, it defaults to 0. Output 2 is the specific heat ratio of the flowing gas. If undefined, it defaults to 1.3.

At the **fourth** channel address:

Source 1 is the temperature in ^{o}F at which the nozzle diameter and pipe diameter were measured.

Output 1 is the coefficient of thermal expansion of the pipe in 10^5 inches/inch/^{o}F. Output 2 is a constant that specifies the type of installation and nozzle (Table 5-8).

Table 5-8. Output 2 Values - Function Code 177

Constant	Installation and Nozzle
0	Incompressible fluid in a throat-tap nozzle
1	Incompressible fluid in a wall-tap nozzle
2	Upstream line pressure measurement in a throat-tap nozzle
3	Upstream line pressure measurement in a wall-tap nozzle
4	Downstream line pressure measurement in a throat-tap nozzle
5	Downstream line pressure measurement in a wall-tap nozzle

5.29.11 Venturi Meter Function (178)

Function 178 measures venturi meter correlation based on the ASME-MFS-3M-1985 standard.

This function occupies four adjacent channels. When you assign it to a channel, the system automatically assigns Function Codes 201, 202 and 203 to the next three higher addressed channels. Digi 4 Plus rejects Function Code 178 unless the next three higher addressed channels have a non-zero function code.

The output data at:

- The first channel is the volume flow at flowing conditions (Q_v) in thousands of cubic feet per hour (MCFH).
- The second channel is the volume flow at base conditions (Q_b) in thousands of standard cubic feet per hour (MSCFH).
- The third channel is the mass flow (Q_m) in thousands of pounds mass per hour (MPPH).
- The fourth channel is the product of the discharge coefficient and the expansion coefficient (C_y); that is, deviation of the flow from the base flow.

The decimal location is 0. at all channels unless redefined. You can assign units.

Parameters

At the **first** channel address:

Source 1[10] is the address of the pressure drop across the venturi meter in inches of water (at 68.0°F with g = 32.174 Ft-lbf/lbm-sec^2). Source 2 is the address of the specific volume of the fluid at flowing conditions in Ft^3/lbm.

Output 1 is the venturi meter diameter in inches. Output 2 is the inside pipe diameter in inches.

At the **second** channel address:

Source 1 is the address of the ratio of the specific volume of the fluid at flowing conditions to the specific volume of the fluid at base conditions (V/V_b). Source 2 is the address of the viscosity of the fluid in units that become centipose when multiplied by the value in Output 2.

---

10. Since most references and most pressure transducer manufacturers convert pressure into an equivalent height of water using the density at 68.0°F and a gravitational constant of 32.174 Ft-lbm/lbf-sec^2 and, since the scaling functions of the Digi 4 Plus can be used to convert the pressure values to any desired units, the venturi meter flow equations of Digi 4 Plus assume the differential pressure is expressed in inches of water at 68F with a gravitational constant of 32.174 Ft-lbm/lbf-sec^2.

If the units of differential pressure are inches of water at 60.0°F and the gravitational constant is 32.17 Ft-lbm/lbf-sec^2 (per AGA-3), the pressure value can be scaled by a linear scaling transfer function whose Input 1 and Input 2 values are both 00.000 with Input 2 equal to 62.362 and Output 2 equal to 62.316.

Output 1 is a constant that is used as a units conversion factor or a meter proof factor. Output 2 is the value of the viscosity multiplier. If Output 1 and Output 2 are undefined, they default to 1.

At the **third** channel address:

Source 1 is the address of the flowing pressure in psia. Source 2 is the address of the flowing temperature in ^{o}F.

Output 1 is the coefficient of the thermal expansion of the material of the venturi meter plate in 10^5 inches/inch/^{o}F. If undefined, it defaults to 0. Output 2 is the specific heat ratio of the flowing gas. If undefined, it defaults to (1.3).

At the **fourth** channel address:

Source 1 is the temperature in ^{o}F at which the venturi meter diameter and pipe diameter were measured.

Output 1 is the coefficient of thermal expansion of the pipe in 10^5 inches/inch/^{o}F. Output 2 is a constant that specifies the type of installation and venturi (Table 5-9).

Table 5-9. Output 2 Values - Function Code 178

Constant	Installation and Venturi Meter
0	Incompressible fluid in a rough cast or fabricated convergent
1	Incompressible fluid in a machined convergent
2	Upstream line pressure measurement in a rough cast or fabricated convergent
3	Upstream line pressure measurement in a machined convergent
4	Downstream line pressure measurement in a rough cast or fabricated convergent
5	Downstream line pressure measurement in a machined convergent

5.29.12 Saturation Pressure of Steam Functions (180-181)

Functions 180-181 calculate the saturation pressure of steam at the measured air temperature.

Code	Description
180	Calculates steam saturation pressure for a temperature input in °F
181	Calculates steam saturation pressure for a temperature input in °C

Parameters

Source 1 is the channel address of the temperature. The input range for Function Code 180 is 32.0°F to 705.47°F; the input range for Function Code 181 is 0°C to 374.15°C. If Source 1 is 000, Input 1 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. The output range for both function codes is 0.08858 to 3208.2 psia or equivalent units.

The decimal location is 0.0 unless redefined. You can assign units.

5.29.13 Saturation Temperature of Steam Functions (182-183)

Function 182-183 calculate the saturation temperature of steam at the measured air pressure.

Code	Description
182	Calculates saturation temperature in °F for a pressure input
183	Calculates saturation temperature in °C for a pressure input

Parameters

Source 1 is the channel address of the pressure. The input range for both function codes is 0.08865 to 700.28 psia or equivalent units. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure.

Output 1 is the value of one atmosphere in the units of pressure used. The output range for Function Code 182 is 32.0°F to 700.28°F; the output range for Function Code 183 is 0.0°C to 371.27°C.

The decimal location is 0.0 unless redefined. You can assign units.

5.29.14 Entropy of Steam Functions (184-185)

Functions 184-185 measure the entropy of steam based on air temperature and pressure.

Code	Description
184	Calculates the entropy of steam for a temperature input in °F
185	Calculates the entropy of steam for a temperature input in °C

Parameters

Source 1 is the channel address of the pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the channel address of the temperature. Input temperatures must be above the saturation line. (See ASME steam tables.) If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 can be used to convert the output data from BTU/lbm to other units.

The decimal location is 0.0000 unless redefined. You can assign units.

5.29.15 Specific Volume of Water Functions (186-187)

Functions 186-187 measure the specific volume of water in Ft^3/lbm using the equations in the ASME steam tables. The specific volume of water is a function of pressure and temperature.

Code	Description
186	Calculates the specific volume of water for a temperature input in °F
187	Calculates the specific volume of water for a temperature input in °C

Parameters

Source 1 is the channel address of the pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the channel address of the temperature. Input temperatures must be below the saturation line. (See ASME steam tables.) If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 can be used to convert the output data from Ft^3/lbm to other units.

The decimal location is 0.0000 unless redefined. You can assign units.

5.29.16 Enthalpy of Water Functions (188-189)

Functions 188-189 calculate the enthalpy of water.

Code	Description
188	Calculates the enthalpy of water for a temperature input in °F
189	Calculates the enthalpy of water for a temperature input in °C

Parameters

Source 1 is the channel address of the pressure. During operation, the pressure is divided by the value at Output 1 in order to obtain the input pressure in atmospheres. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the channel address of the temperature. Input temperatures must be below the saturation line. (See ASME steam tables.) If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 can be used to convert the output data from BTU/lbm to other units.

The decimal location is 0.0000 unless redefined. You can assign units.

5.29.17 Entropy of Water Functions (190-191)

Functions 190-191 calculate the entropy of water.

Code	Description
190	Calculates the entropy of water for a temperature input in °F
191	Calculates the entropy of water for a temperature input in °C

Parameters

Source 1 is the channel address of the pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the channel address of the temperature. Input temperatures must be below the saturation line. (See ASME steam tables.) If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used. Output 2 can be used to convert the output data from BTU/lbm to other units.

The decimal location is 0.0000 unless redefined. You can assign units.

5.29.18 Isentropic Efficiency of Turbine Stage Functions (192-193)

Functions 192-193 calculate the isentropic efficiency and isentropic exhaust enthalpy of a steam turbine stage.

These function codes occupy two adjacent channels. When you assign them to a channel, the system automatically assigns Function Code 201 to the next higher channel address. Digi 4 Plus rejects Functions 192 and 193 unless the next higher addressed channels haves a non-zero function code.

The output data at:

- o The first channel is the isentropic efficiency
- o The second channel is the isentropic exhaust enthalpy.

The default decimal location 0.00 at the first channel and 0. at the second channel. You can redefine the decimal code and assign units at both channels.

Code	Description
192	Calculates the isentropic efficiency and exhaust enthalpy in °F
193	Calculates the isentropic efficiency and exhaust enthalpy in °C

Parameters

At the first channel address:

Source 1 is the inlet pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the inlet temperature. If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used.

At the second channel address:

Source 1 is the exhaust pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the exhaust temperature. If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

5.29.19 Exhaust Quality/Enthalpy of Turbine Stage Functions (194-195)

Functions 194-195 calculate the exhaust state quality and enthalpy of a turbine stage based on a known isentropic efficiency.

These function codes occupy two adjacent channels. When you assign them to a channel, the system automatically assigns Function Code 201 to the next higher channel address. Digi 4 Plus rejects Functions 194 and 195 unless the next higher addressed channels have a non-zero function code.

The output data at:

- o The first channel is the quality of the exhaust state
- o The second channel is the enthalpy of the exhaust state

0. is the default decimal location at both channels. You can redefine the decimal code and assign units at both channels.

Code	Description
194	Calculates the exhaust state quality and enthalpy in ^{o}F
195	Calculates the exhaust state quality and enthalpy in ^{o}C

Parameters

At the first channel address:

Source 1 is the inlet pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the inlet temperature. If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

Output 1 is the value of one atmosphere in the units of pressure used.

At the second channel address:

Source 1 is the exhaust pressure. If Source 1 is 000, Input 1 can be assigned the constant that specifies the pressure. Source 2 is the isentropic efficiency of the exhaust state. If Source 2 is 000, Input 2 can be assigned the constant that specifies the temperature.

5.30 ZERO OFFSET FUNCTION (199)

Function 199 serves two distinct purposes. Use it to display the zero offset or the number of bytes in the text output buffer.

Parameters

To display the number of bytes in the text output buffer, assign Function 199 to a channel or CALC channel address. You do not have to define any other parameters. The text output can store up to 8183 bytes of user-defined reports and messages. 3 bytes are reserved for the system.

To display the zero offset and use it to calibrate the system or as a diagnostic tool for the built-in analog scanners, assign Function 199 to a channel or CALC channel address and define Source 1.

Digit 1 is always zero.

Digit 2 is voltage range; valid entries are 0-4.

0 = 30.000mV (displayed with 1/2 microvolt resolution)
1 = 60.000mV
2 = 600.00mV
3 = 6.0000V
4 = 12.000V

Digit 3 is the number of the built-in analog scanner. The value assigned depends upon the voltage range selected in Digit 2. If Digit 2 specifies the 30mV or 60mV voltage range, Digit 3 can be any number 1-8. This number corresponds to the number of the built-in analog scanner. If Digit 2 specifies the 600mV, 6.0V or 12V voltage range, Digit 3 must be 1.

An open circuit results on the 30mV or 60mV range if Digit 3 is assigned a number greater than the number of built-in analog scanners. For example, if your system has 3 analog scanners and you assign a 4 to Digit 3, an open circuit results. An open circuit results on the 600mV, 6.0V or 12V range if you assign Digit 3 a number greater than 1.

The Digi 4 Plus automatically calculates the zero width. To display the zero width and use it as a diagnostic, assign 010 to Source 1. If the zero width is less than 60 or greater than 100, check the calibration of the 4 Plus Analog board (60.000 mV range.) See the Digi 4 Plus Maintenance Manual for more information.

Each analog scanner has an internal RTD that measures the temperature of the uniform temperature reference (UTR). To display the voltage output (without decimal) of the RTD, assign 009 to Source 1.

Source 2 is not used.

Operation

The system uses the average of four readings from a shorting relay to calculate the zero offset for a specified voltage range. The zero offset represents the additive inverse of the error value that the system sees with a shorted input. For example, if the system sees a shorted input as -00.059, the zero offset value is 00.059. The system software adds 00.059mV to readings made on that range and terminal bank. The decimal in the displayed data is in the same position as the specified voltage range.

If you specify the 30mV or 60mV range, the system can calculate the zero offset for each built-in analog scanner with the DVM. On the 600mV, 6.0V and 12V ranges, the system calculates the zero offset for built-in analog scanner 1 and the DVM. The system does not allow for differences between individual scanners on these higher ranges because that the discrepancies between scanners are negligible on these ranges.

Example: Assign Function Code 199 to Channel Address 104 in order to display the zero offset for the 6.0V range. Source 1 = 031; 3 represents the 6.0V range; 1 represents built-in analog scanner #1.

Channel Address 104 displays the zero offset value. The figure below shows a zero offset value (0.0038).

5.31 AUTOMATIC DATA STORAGE FUNCTIONS (201-209 and 211)

The system automatically assigns automatic data storage functions. They are non-operating functions that reserve channels for data storage. When you assign a meter, counter, sequencer, specific volume of natural gas, orifice flow, compressor efficiency or PID control function, the system automatically assigns one or more automatic data storage functions to the next higher addressed channel or channels.

The channel reserved for automatic data storage must be assigned Function 000. For example, the meter function requires one reserved channel. The system will not accept a meter function assignment at Channel 610 unless Channel 611 is assigned Function 000. If Channel 611 has Function 000, the system automatically assigns Function 211 to Channel 611 as soon as you assign the meter function to Channel 610.

The assigned function determines the number of channels required for data storage. Certain functions may require you to assign values to specific parameters. You can redefine the decimal code at Function 201-209 channels; the decimal code at the Function 211 channel is fixed by the system. You can enter limits at Function 201-209 channels.

SECTION 6 - SOURCES

6.1 GENERAL INFORMATION 6-1

6.2 SYSTEM INPUT DATA 6-1

6.3 NUMERICAL INPUT DATA 6-2
6.3.1 Channels and CALC Channels 6-2
6.3.2 Global System Parameters 6-3
6.3.3 Constants 6-6

6.4 LOGICAL INPUT DATA 6-7

6.5 SYSTEM TIMERS 6-11

6.1 GENERAL INFORMATION

A source specifies the location of channel and CALC channel input data or a number of samples. Channels and CALC channels can have two sources: Source 1 and Source 2. These sources can contain numerical or logical data. The function code determines the number and type of sources. A function code may require numerical input data, logical input data or both. Table 6-1 lists the sources.

Table 6-1. Sources

Numerical Data	Addresses
System input (implied source)	000
CALC channels	001-099
Channels	101-816
Global system parameters	901-916
Historical buffers	001-016
Number of buffer entries (Historical buffer functions only)	001-032
Constants (Multi-segment and polynomial functions only)	001-099

Logical Data	Addresses
Always true logic bit	000
Relay logic bits	001-048
Odd master relay logic bit	049
Even master relay logic bit	050
Status input logic bits	051-082
Analog scan logic bit	083
Power-on logic bit	084
Set by terminal/computer	085-088
Program altered	090
LOG key/operator panel	091
Command 110 from computer	092
OR of 091 and 092	093
ALARM LOG/operator panel	094
Command 111 from computer	095
OR of 094 and 095	096
Printer needs service	097
Printer off-line	098
Always false logic bit	099
Channel logic bits	101-816
System timer logic bits	901-916

6.2 SYSTEM INPUT DATA

System input data comes from a sensor connected directly to the terminal bank of a Digi 4 Plus input scanner or from an external scanner such as a DS-8 or FS-8. Function Codes 001-050 (voltage, linear, thermocouple, RTD, and multi-segment linear) are system input function codes. When system input data enters Digi 4 Plus, it is stored in the input buffer and transferred to the channel address at the beginning of the next math scan. CALC channels do not accept system input data.

Analog Sensor Inputs

Analog sensor inputs can come from voltages, currents, thermocouples and RTD's.

Voltage inputs are in the +/-60.000mV, +/-600.00mV, +/-6.0000V and +/-12.000V range. For measurements above 12V, place a voltage divider (VD-100) across the appropriate terminal bank on the Digi 4 Plus. The VD-100 reduces input voltage by a factor of 100.

Digi 4 Plus can measure transducers with a direct current output such as a 4-20mA or 10-50mA output if you place a precision shunt resistor across the input terminals to produce a voltage. For example, if a 4-20mA signal is measured with a precision 62.5 ohm shunt resistor across the input terminals, the input voltage is between 0.25 to 1.25 volts (250 to 1250mV).

Thermocouple inputs are type B, C, E, J, K, N, R, S, and T (0.1°C or 0.1°F resolution). Type T is also measured to 0.01°C resolution.

RTD inputs are 100 ohm platinum 3-wire bridge or 4-wire 1mA (0.1°F, 0.1°C or 0.01°C resolution) and 10 ohm copper 3-wire bridge (0.1°F or 0.1°C resolution).

External Scanner Inputs

External scanner inputs can come from another Digi 4 Plus, a DS-8 or an FS-8. Digi 4 Plus treats the inputs as millivolt readings. See Section 2 and the documentation supplied with your scanner for more information.

6.3 NUMERICAL INPUT DATA

Numerical data is stored at channels, CALC channels, global system parameters, historical buffers and constant addresses. Depending on the assigned function code, it can be either displayed or extended precision.

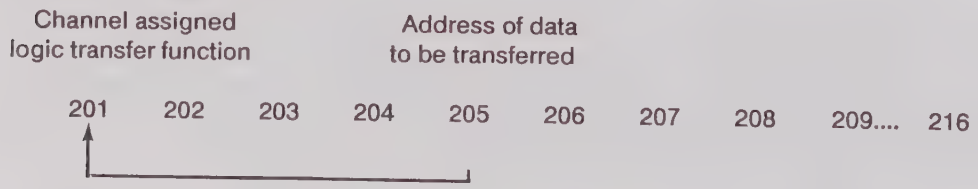
6.3.1 Channels (101-816) and CALC Channels (001-099)

All channels and CALC channels can store numerical data. Digi 4 Plus updates channel and CALC channels in ascending order, beginning with CALC Channel 001. To make sure a channel or CALC channel receives the most recent data, the Source 1 and Source 2 addresses should be lower than the channel or CALC channel receiving the source data.

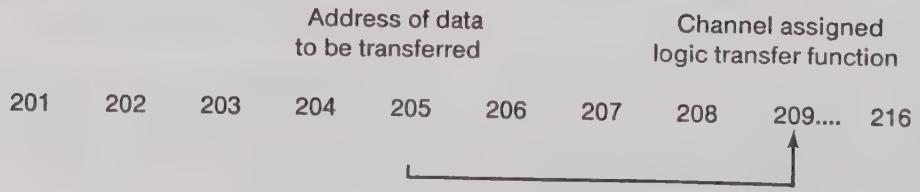
The examples below show the effect of higher and lower addresses as sources.

Example: Channel Address 205 is measuring a temperature. Assign Function Code 114 (transfer) to continually send temperature readings from Channel 205 to another channel.

If you assign Function Code 114 to Channel Address 201 and specify Channel Address 205 as the source of the input data, Digi 4 Plus updates Channel 201 before updating Channel 205. Data from the previous math scan, not the current one, is transferred from Source 1 (Channel 205) to Channel 201.



If you assign Function Code 114 to a higher address (Channel 209) and specify Channel Address 205 as the source of the input data, Digi 4 Plus updates Channel 205 before updating Channel 209. The most recent data is transferred from Source 1 (Channel 205) to Channel 209.



6.3.2 Global System Parameters (901-916)

A global system parameter stores information about the internal operation of the entire system. Global system parameters are not assigned channels parameters nor do they output logical data, but you can specify them as sources. Table 6-2 lists the information stored at each address.

Table 6-2. Global System Parameters

Channel Address	Stores	
901	Compensator voltage for built-in scanner #1	
902	Compensator voltage for built-in scanner #2	
903	Compensator voltage for built-in scanner #3	
904	Compensator voltage for built-in scanner #4	
905	Compensator voltage for built-in scanner #5	
906	Compensator voltage for built-in scanner #6	
907	Compensator voltage for built-in scanner #7	
908	Compensator voltage for built-in scanner #8	
909	Reserved	
910	Math scan time	(0.00 sec)
911	Analog scan time	(0.00 sec)
912	Real time clock	(HHMM.S)
913	Day of the week	(1-7)
914	Month and day	MM.DD)
915	Duration of last power-off	(min)
916	Running hours since last initialization (hrs)	

Channel Addresses	Purpose
901-908	Store a voltage reading. The voltage is the output of an RTD sensor that measures the temperature of the UTR assembly at each terminal bank. Digi 4 Plus uses the voltage to calculate the cold junction compensation voltage for each type of thermocouple.
910-911	Store time information. Channel 910 stores the math scan time (the number of seconds the system requires to process all channels). The complexity of the program affects the math scan time. Channel 911 stores the analog scan time. It is 40 channels per second at 60 Hz and 33 1/3 channels per second at 50 Hz (with one channel of overhead per scan and one channel of overhead per bank).
912-914	Store time and date information. Channel 912 displays hours, minutes and seconds of the real time clock. Channel 913 contains a number (1-7) that represents the day of the week. You establish the relationship between the numbers and the day when you set the real time clock. Channel 914 stores the date: month and day.

Channel Addresses	Purpose
915	Duration of last power-off. Stores the minutes of the last power outage.
916	Time since last initialization. Keeps track of the number of whole hours Digi 4 Plus has been running since initialization.

To display the data stored at a global system parameter:

- o Press the CHANNEL key. The upper display contains the address of the last channel accessed.
- o Key in the channel address or press the INCREMENT or DECREMENT key to access the channel address. The lower display contains the stored information.

6.3.3 Historical Buffers (01-16)

An historical buffer is a first-in, first-out (FIFO) buffer used for temporary storage. It can store up to 32 data samples. An historical buffer has two sources: Source 1 and Source 2.

Source 1 is the channel address of the input data.

Source 2 is a logic address. The logic bit at this address governs the time interval between each sample entry. When the logic bit makes a false/true transition, a new data sample from Source 1 enters the buffer. (If the logic address is a system timer, you must assign a time interval and reset time to the system timer.)

You can use the data in an historical buffer with Functions 067-074. Enter the buffer address (01-16) as a three-digit number (001-016).

You can also include the contents of an historical buffer in a data report. The data samples provide a chronological record of displayed output data from one address. When historical buffer data is included, it follows channel output data.

The historical buffer operates in this way:

1. Digi 4 Plus updates data at all channel addresses.
2. A sample data from Source 1 enters the buffer when the Source 2 logic bit makes a false/true transition.
3. After each false/true transition, another data sample enters the buffer. The most recent sample always enters Sample 001. Other samples move to the next number. For example, the data at Sample 001 moves to Sample 002; data at Sample 002 moves to Sample 003. If the buffer contains 32 samples, data at Sample 032 leaves when a new sample enters.
4. If the source data is open or over-range, an OPEN or OVRNG reading enters the buffer. Digi 4 Plus does not include these readings in calculations and selections for historical buffer functions.

If the buffer already contains data samples, we recommend that you clear it to make sure that only data samples from the current Source 1 address are included in calculations and/or selections. Function Code 074 (clear buffer function) automatically clears the buffer.

If you have not assigned sources to a buffer, there is no need to clear it. Digi 4 Plus automatically clears buffers when the system is initialized and after a cassette program load. Open readings are stored in all sample locations.

Example: Send samples of input data from Channel Address 411 to Historical Buffer 06 every two minutes. (Channel 411 is monitoring thermocouple readings: Source 1 = 411 and Source 2 is a System Timer 07 assigned a 2 minute time interval.) System Timer 07 controls the logic bit at Logic Address 907. Table 6-3 shows the contents of the buffer the first time System Timer 07 resets, after 18 minutes, after 38 minutes and after 64 minutes.

Table 6-3. Contents of Historical Buffer 06

Sample Number	Reset Time	After 18 Min.	After 38 Min.	After 64 Min.
001	32.6	33.0	34.0	31.8
002	OPEN	33.4	34.4	32.4
003	OPEN	35.6	34.6	32.6
004	OPEN	34.8	OPEN	32.5
005	OPEN	34.5	33.5	32.0
006	OPEN	33.9	33.9	32.1
007	OPEN	34.2	33.2	32.4
008	OPEN	33.7	32.7	32.2
009	OPEN	33.1	32.5	32.5
010	OPEN	32.6*	32.5	32.5
011	OPEN	OPEN	33.0	32.9
012	OPEN	OPEN	33.4	33.2
013	OPEN	OPEN	35.6	33.9
014	OPEN	OPEN	34.8	34.0
015	OPEN	OPEN	34.5	34.4
016	OPEN	OPEN	33.9	34.6
017	OPEN	OPEN	34.2	OPEN
018	OPEN	OPEN	33.7	33.5
019	OPEN	OPEN	33.1	33.9
020	OPEN	OPEN	32.6*	33.2
021	OPEN	OPEN	OPEN	32.7
022	OPEN	OPEN	OPEN	32.5
023	OPEN	OPEN	OPEN	32.5
024	OPEN	OPEN	OPEN	33.0
025	OPEN	OPEN	OPEN	33.4
026	OPEN	OPEN	OPEN	35.6
027	OPEN	OPEN	OPEN	34.8
028	OPEN	OPEN	OPEN	34.5
029	OPEN	OPEN	OPEN	33.9
030	OPEN	OPEN	OPEN	34.2
031	OPEN	OPEN	OPEN	33.7
032	OPEN	OPEN	OPEN	33.1

* First data sample in the buffer.

At Reset Time the first temperature reading (32.6) enters the buffer when the logic bit at Logic Address 907 makes a false/true transition. OPEN readings are stored in Samples 002 to 032 until they receive a temperature reading.

After 18 Minutes Timer 07 has reset 10 times, causing 10 temperature readings to enter the buffer. The second temperature reading enters the buffer at the first two minute interval, the third at the second two minute interval. Notice that 32.6 is now stored in Sample Number 010. OPEN readings are stored in Samples 011 to 032 until they receive a temperature reading.

After 38 Minutes Timer 07 has reset 20 times, causing 20 temperature readings to enter the buffer. Notice that 0032.6 is now stored in Sample 020. OPEN readings are stored in Samples 021 to 032 until they receive a temperature reading. An OPEN reading is stored in Sample 004 because the thermocouple at Channel 411 was open circuit when the sample entered the buffer.

After 64 Minutes Timer 07 has reset 33 times; there are 32 temperature readings in the buffer. Notice that 0032.6, the first temperature reading, is no longer there. It moved out to make room for additional samples. Notice that the OPEN is now stored in Sample 017.

To assign sources:

- Press the BUFFER key. The upper display contains the address of the last buffer accessed. The lower display is blank.
- Press the INCREMENT or DECREMENT key to access the buffer address, or key in key in the address and press the ENTER key.
- Press the SOURCE key. The leftmost position in the upper display contains a 1 (Source 1). The lower display contains the channel address from which data samples are taken. If you did not assign an address to Source 1, the lower display contains zeros. The alphanumeric display contains an S.
- Assign a value to Source 1 and press the ENTER key.
- Press the SOURCE key again. The upper display contains the address of the logic bit controlling the entry of data samples. The leftmost corner of the upper display contains a 2 (Source 2). If you did not assign a logic address to Source 2, the lower display contains zeros. The alphanumeric display contains an S.
- Assign a value to Source 2 and press the ENTER key.

To access other buffers and view their sources, press the INCREMENT or DECREMENT keys.

To clear an historical buffer, assign Function 075. See Section 5 for more information.

6.3.3 Constants (01-99)

A constant address stores two user-defined, five-digit values: input and output constants. When you use a constant as a source, enter it as a three-digit number (001-099).

A constant can specify:

- Endpoints in a segmented curve fit. Use them with Function Codes 047-050 (multi-segment input) and Function Code 054 (multi-segment transfer). Input and output values at each consecutive constant address define a segment endpoint.

- Constants in a polynomial equation. Used them with Function Code 099 (polynomial transfer). The input and output values define a polynomial constant.

  Polynomial constant = (Output x 10^{Input})

The values must fit the 65535 display capacity with the following resolution: +/-65535., +/-6553.5, +/-655.35, +/-65.535, +/-6.5535. You cannot place a decimal in the leftmost position.

To assign an input constant:

- Press the CONSTANT key. The upper display contains the last constant address accessed. The lower display is blank.
- Press the INCREMENT or DECREMENT key to access the address, or key in the address and press the ENTER key.
- Press the INPUT key. The lower display contains the input value. If you did not assign a value, it is blank. The alphanumeric display contains an I (input).
- Assign a value and press the ENTER key.
- Assign a NULL value to the input parameter at the constant address immediately following the last defined term or endpoint.

To assign an output constant:

- Press the OUTPUT key. The lower display contains the output value. If you did not assign a value, it is blank. The alphanumeric display contains an O (output).
- Assign a value and press the ENTER key.

If you do not assign a value to a constant address, the OPEN CIRCUIT light goes on.

If you null the input or output parameter, the lower display goes blank. To null the input or output parameter:

- Press the CONSTANT key, key in the constant address and press the ENTER key.
- Press the INPUT or OUTPUT key.
- Press the NULL and ENTER keys.

6.4 LOGICAL INPUT DATA

A logic bit is an indicator that signals an on or off condition. When a logic bit is on, it is true. When a logic bit is off, it is false. A logic bit can be true or false for one or more math scans.

The state of a logic bit is stored at a logic address. All defined channels (but not CALC channels) output a logic bit. In addition, Digi 4 Plus has 116 system logic addresses that can output logic bits.

You can use logical data as input data to a function, or it can initiate reports, release data from the text output buffer or define a set of system logic conditions for the sequencer function.

To view the state of a logic bit, press the CHANNEL key and key in the logic address. If the logic bit is true, the upper display contains a decimal point to the left of the logic address. If it is false, that space is blank.

Table 6-4 lists the logic addresses.

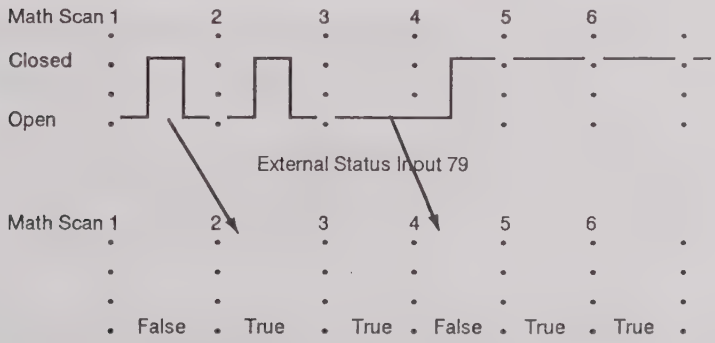
Table 6-4. Logic Addresses

Logic Addresses	Description
000	Always true logic bit
001-048	Relay logic bits
049	Odd master relay logic bit
050	Even master relay logic bit
051-082	Status inputs
083	Turns momentarily true at the end of each analog scan
084	Turns true for one math scan at power-on
085-088	Can be set true for one math scan via computer extended interface (CXT) or terminal interface (TRM)
090	Turns TRUE when the program is altered
091	Turns momentarily true when you press the LOG key
092	Turns momentarily true when Command 110 is issued via Communications Port CXT protocol
093	The OR of 091 and 092
094	Turns momentarily true when you press the ALARM LOG key
095	Turns momentarily true when Command 111 is issued via communications port CXT protocol
096	The OR of 094 and 095
097	Turns true when printer needs service; stays true until problem is corrected
098	Turns true when printer is off-line; stays true until printer is on-line
099	Always false logic bit
101-816	Channel logic bits
901-916	System timer logic bits. Logic bit turns true when timer resets

The following pages describe controls for each logic bit.

Logic Addresses	Control
000	Digi 4 Plus sets this logic bit; it is always true.
001-048	Relays 01-48, respectively, control these logic bits. A relay logic bit is true during the math scan immediately following activation of its corresponding relay. Assigned limits and op-codes or the sequencer function can activate a relay. A relay logic bit is false during the math scan immediately following deactivation of the corresponding relay. If you assign the same relay to more than one limit op-code or sequencer, the relay logic bit remains true as long as any limit or sequencer requires its activation.
049	The odd master relay controls this logic bit. It is true during the math scan immediately following activation of the odd master relay. It remains true as long as any relay requires its activation. It is false during the math scan immediately following deactivation of the odd master relay.

Logic Addresses	Control
050	The even master relay controls this logic bit. It is true during the math scan immediately following activation of the even master relay. It remains true as long as any relay requires its activation. It is false during the math scan immediately following deactivation of the odd master relay.
051-082	Status inputs 51-82, respectively, control these logic bits. Digi 4 Plus can monitor the status of up to 32 digital inputs. A status input can detect the on/off condition of an input. A voltage input signal is latched and makes the logic bit true. When the voltage drops to zero, the logic bit is reset to zero at the end of the next math scan. A contact must be closed a minimum of 30 milliseconds to turn on the status input logic bit. To make sure the system detects an off state, the contact must be open for two math scans. The example below shows how status inputs control their logic bits. <u>Example</u>: Connect an on/off switch to Status Input 79. When the switch is ON, a closed contact occurs across the external status input and the logic bit at Logic Address 079 is set true during the next math scan. When the switch is off, an open contact occurs across the external status input. The illustration below shows the effect of a closed or open contact on the corresponding logic bit (079).



State of Logic Bit at Logic Address 079

083	The analog scan controls this logic bit. It is set true (if it was false) at the end of each analog scan and never remains true for more than one math scan.
084	Digi 4 Plus controls this logic bit. It is true for the next math scan following a power-on. You can use Logic Address 084 as a source when you want a special action to occur; for example, generation of a report when power returns.
085-088	A computer or terminal can set these logic bits true. See Section 11 for more information.

Logic Addresses	Control
090	This logic bit is true when Digi 4 Plus is in the Program mode from either the operator panel or computer interface. It resets to false when you generate a list program of all classes of modified parameters on the local printer when Digi 4 Plus not in the Program mode. The logic bit also turns true when you load a program via Kaye's Cassette Program Loader (CPL-2). It remains in true until you generate a list program on the local printer when Digi 4 Plus is not in the Program mode.
091	The LOG key controls this logic bit. It is true during the math scan immediately following the one in which you pressed the LOG key.
092	Command 110 of the Communications Port CXT protocol controls this logic bit. It is true for one math scan.
093	This logic bit is true when either Logic Address 091 or Logic Address 092 is true. It remains true for one math scan.
094	The ALARM LOG key controls this logic bit. It is true during the math scan immediately following the one in which you pressed the ALARM LOG key.
095	Command 111 of the Communications Port CXT protocol controls this logic bit. It is true for one math scan.
096	This logic bit is true when either Logic Address 094 or Logic Address 095 is true. It remains true for one math scan.
097	The Digistrip 4 Plus internal printer controls this logic bit. It is true when the printer is out of paper or the paper jams. It remains true until you correct the problem.
098	The Digistrip 4 Plus internal printer controls this logic bit. It is true when the printer is off-line and remains true until the printer is back on-line.
099	Digi 4 Plus sets this logic bit; it is always false.
101-816	Limits and op-codes control these logic bits, except when the assigned function code outputs only logical data. In that case, the function code determines the state of the channel logic bit. When Digi 4 Plus processes a channel, it updates the data and the state of the channel logic bit during the same math scan.
901-916	System Timers 01-16 control these logic bits. Each system timer controls a logic bit that is set true during the math scan immediately following reset of the timer. The logic bit is false at all other times.

6.5 SYSTEM TIMERS

Digi 4 Plus has 16 system timers. Each system timer controls a logic bit that is set momentarily true when the timer resets. System timers are synchronized to the system clock. The system clock is battery backed-up and continues to run for up to two weeks if the power is turned off. If the system clock is changed, the system timers are automatically updated.

Digi 4 Plus compares the reset time of each system timer to the system clock. When the two are equal (the reset time equals real time) the logic bit controlled by the system timer turns momentarily true and Digi 4 Plus automatically calculates a new reset time. The reset time is updated by the value of the time interval; it computes the proper number of days for each month, including Leap Year.

The state of a system timer logic bit is stored at a logic address. System Timers 01-16 correspond to Logic Addresses 901-916. For example, Logic Address 911 stores the logic bit controlled by System Timer 11. The logic bit at Logic Address 911 is true during the math scan immediately following the reset of System Timer 11. At all other times, it is false.

System Timer 16 also sets the time interval for the rate-of-change limit.

You assign input and output parameters to a system timer.

Input Parameter

The input parameter specifies the interval between resets. It contains an eight-digit entry that represents the number of days, hours, minutes and tens of seconds between resets. The first two digits are in the upper display; the lower display contains the other six digits. Digi 4 Plus inserts decimals to separate the units.

Digits 1 and 2 specify the number of days. Valid entries are 00 to 28.

Digits 3 and 4 specify the number of hours. Valid entries are 00 to 23.

Digits 5 and 6 specify the number of minutes. Valid entries are 00 to 59.

Digits 7 and 8 specify the tens of seconds. You enter only Digit 7. Valid entries are 0, 1, 2, 3, 4 or 5. Digi 4 Plus inserts Digit 8, which is always a zero.

To define the time interval:

- Press the TIMER key. The upper display contains the address of the last system timer accessed. The lower display is blank.
- Press the INCREMENT or DECREMENT key to access the system timer address or key in the address and press the ENTER key.
- Press the INPUT key. The display contains the time interval between resets. If you did not assign a value or if you nulled it, the display contains zeros. The alphanumeric display contains an I (input). The two rightmost digits of the upper display show the number of days in the time interval; the lower display shows the hours, minutes and seconds. A decimal point separates the units of time.
- Key in the day, hour, minute and tenths of a second time interval and press the ENTER key. (For a one month interval, enter zeros.)

Example:

Interval	Input
1-minute	00.00.01.00
8-hour	00.08.00.00
7-day	07.00.00.00
36-hour	01.12.00.00

To specify a 1 month interval, assign zeros to the input parameter and assign the exact reset time to the output parameter.

Output Parameter

The output parameter specifies the first reset time (date and time the next interval begins). Digi 4 Plus compares the reset time of each system timer to the system clock. When the two are equal (the reset time equals real time), the logic bit controlled by the system timer turns momentarily true and Digi 4 Plus automatically calculates a new reset time. The reset time updates by the value of the time interval; it computes the proper number of days for each month, including leap year.

Digi 4 Plus automatically increments the reset time at the end of each time interval by the value assigned the input parameter. The output parameter is an eight-digit entry that represents the date and time of day the timer resets and the next time interval begins. The first two digits are in the upper display; the lower display contains the other six digits. Digi 4 Plus inserts decimals to separate the units.

Digits 1 and 2 specify the day the timer resets. Valid entries are 01 to 31.

Digits 3 and 4 specify the hour the timer resets. Valid entries are 00 to 23 (00 = midnight).

Digits 5 and 6 specify the minute the timer resets. Valid entries are 00 to 59.

Digits 7 and 8 specify the tens of seconds in the time interval. You enter only Digit 7. Valid entries are 0, 1, 2, 3, 4 or 5. Digi 4 Plus inserts Digit 8, which is always a zero.

To assign a value to the reset time parameter:

- Press the TIMER key. The upper display contains the address of the last system timer accessed.
- Press the INCREMENT or DECREMENT key to access the system timer address, or key in the address and press the ENTER key.
- Press the OUTPUT key. The display contains the reset time. The last two digits of the upper display show the day of the reset; the lower display shows the time of the reset in hours, minutes, and tenths of a second. A decimal point separates the units of time. If you did not assign a reset time or if you nulled it, the display contains zeros. (A reset time of zero disables the system timer.) The alphanumeric display contains an O (output).
- Enter the date and time of the first reset and press the ENTER key. Digi 4 Plus interprets the time you enter as future time. You must assign a value to this parameter or reset never begins. Digi 4 Plus compares the value with real time and the resets system timer when the two are equal.

Example: Specify a reset time of 5:30 AM on the 21st of the month (21.05.30.00).

The system timer resets on the 21st day of the current month, or the 21st day of the next month, depending on the date of the entry. For example, if you specify a reset time of 2105300 on the 10th of May, the system timer resets the 21st of May. However, if you specify a reset time of 2105300 on the 27th of May, it resets the 21st of June.

To have a system timer reset the same date and time every month:

- Assign all zeros to the input parameter.

and

- Enter the date and time you want the system timer to reset every month in the output parameter.

Example:

Reset	Output
First day of the month at 8:00 AM	01.08.00.00
Last day of the month at midnight	01.00.00.00

To define a timer to reset on the last day of the month at midnight, assign a reset time equal to first day of the month. If you specify the 31st day of the month as the reset time, it resets on the 31st of each month. It will not reset in a month with fewer than 31 days. You must tell Digi 4 Plus when to reset a system timer; a reset time of zero disables the system timer.

If power fails but returns before the reset time:

- A printout shows the date and the time power failed, and the date and time it returned.
- The reset occurs at the specified time and the timer continues normal operation.

Example: System Timer 03 is due to reset at 6:00 PM. The interval between resets is 12 hours. Power fails at 2:00 PM and returns at 4:00 PM. At 4:00 PM, a printout shows the time power failed and the time it returned. System Timer 03 resets at 6:00 PM, the logic bit at Logic Address 903 is set momentarily TRUE and the system recalculates the new reset time as 6:00 AM.

If power fails but does not return until after a specified reset time:

- A printout shows the time power failed and the time it returned.
- The system timer is reset and its logic bit is set true for the math scan following the return of power.
- Digi 4 Plus automatically calculates a new reset time, based on the time interval and the last reset time.

Example: System Timer 03 is due to reset at 6:00 PM. The interval between resets is 12 hours. Power fails at 2:00 PM and returns at 8:00 AM. At 8:00 AM, a printout shows the time power failed and the time it returned. System Timer 03 resets at 8:00 AM, the logic bit at Logic Address 903 is set momentarily TRUE and the system recalculates the new reset time as 6:00 PM.

SECTION 7 - LIIMITS, LIMIT OP-CODES AND RELAYS

7.1 GENERAL INFORMATION 7-1

7.2 LIMITS 7-1
7.1.1 High and Low Limits 7-1
7.1.2 Rate-of-Change Limit 7-1

7.3 LIMIT OP-CODES 7-3
7.3.1 Limit Op-Code 1 7-5
7.3.2 Limit Op-Code 2 7-6
7.3.3 Limit Op-Code 3 7-8

7.4 RELAYS. 7-9
7.4.1 Logical Relays 7-9
7.4.2 Master Relays 7-9
7.4.3 Watchdog Relay 7-11
7.4.4 Optional Physical Relays 7-11

7.1 GENERAL INFORMATION

Limits set the bounds against which Digi 4 Plus compares channel output data. Limit op-codes control the action Digi 4 Plus takes when channel output data goes out of limits, returns within limits or returns from open circuit or over-range. CALC channels do not accept limits or limit op-codes.

7.2 LIMITS

A limit is a five-digit value that sets a bound against which Digi 4 Plus compares channel output data.

Each channel can accept two independently assignable limits: Limit 1 and Limit 2. Limit 1 can be high, low or rate-of-change. Limit 2 can be high or low.

If a function code outputs logical data you cannot set limits, but you can define limit op-codes. Limit 1 op-codes are used when the channel logic bit is true; Limit 2 op-codes are used when the channel logic bit is false.

Digi 4 Plus automatically places the decimal in the same position as the decimal code. Assign the function code and decimal code before the limits; limits are nulled if you change either of these codes. To reactivate limits, press the LIMIT TYPE and ENTER keys. When you reactivate limits, the same numbers reappear; if the decimal was moved, the value of the limit is changed by a multiple of ten.

7.1.1 High and Low Limits

High and low limits are self-explanatory. Assign the high trip point to the high limit, and the low trip point to the low limit.

7.1.2 Rate-of-Change Limit

A rate-of-change limit specifies a bound on the fluctuation that can occur in channel output data during the interval specified by System Timer 16.

At the beginning of each interval, Digi 4 Plus stores the first sample of channel output data as a base value. It compares each successive output value to the base value.

If there is no change greater than or equal to the limit during the interval:

- The timer resets
- A new time interval begins
- The stored sample is updated to set a new base value
- The comparison of data values with the base value continues until the limit is exceeded or the time interval ends

If there is a change greater than or equal to the assigned limit during the interval:

- A trip occurs (Digi 4 Plus initiates the action specified by the assigned limit op-codes)
- The most recent output value updates the stored sample to set a new base value
- The comparison of data values to the new base value continues until the limit is exceeded again or the time interval ends

Example: A transducer monitors the temperature of a liquid. The temperature should not change more than 10° C during a 5 minute interval. Assign a rate-of-change limit so appropriate action is taken if a change greater than or equal to 10° occurs (Figure 7-1).

If there is a change of 10° C during the interval, limit op-codes tell Digi 4 Plus what action, if any, to take. (You can assign a value less than 10 so you are warned before the 10 degree change occurs.) System Timer 16 controls the time interval of the rate-of-change limit. Assign it a 5 minute interval.

At the beginning of the first interval, the temperature is 20°C. 20 is the base value; 20 +/- 10 is the limit bounds. A trip occurs if the channel output data is ≥30°C or ≤10°C. During the first interval, the temperature rises to 30°C and a trip occurs. Digi 4 Plus initiates the actions specified by the limit op-codes. 30 becomes the new base value and 30 +/- 10 the new limit.

At the end of the first interval, System Timer 16 resets aand another 5 minute interval begins. 38 becomes the new base value. During the interval, there is no temperature difference greater than or equal to 10 degrees.

At the end of the second interval, System Timer 16 resets, another 5 minute interval begins and 40 becomes the new base value and 40 +/- 10 the new limits. A trip occurs if the channel output data is ≥50°C or ≤30°C. During the third interval, there is no temperature difference greater than or equal to 10 degrees.

At the end of the third interval, System Timer 16 resets and another 5 minute interval begins. 48 becomes the new base value and 48 +/- 10 the new limits. During the interval the temperature rises to 58°C. A trip occurs, and Digi 4 Plus initiates the action specified by the limit op-codes. 58 becomes the new base value and 58 +/- 10 the new limits.

At the end of the fourth interval, System Timer 16 resets and another time interval begins. 64 becomes the new base value and 64 +/- 10 the new limits. During the fifth interval, there is no temperature difference greater than or equal to 10 degrees.

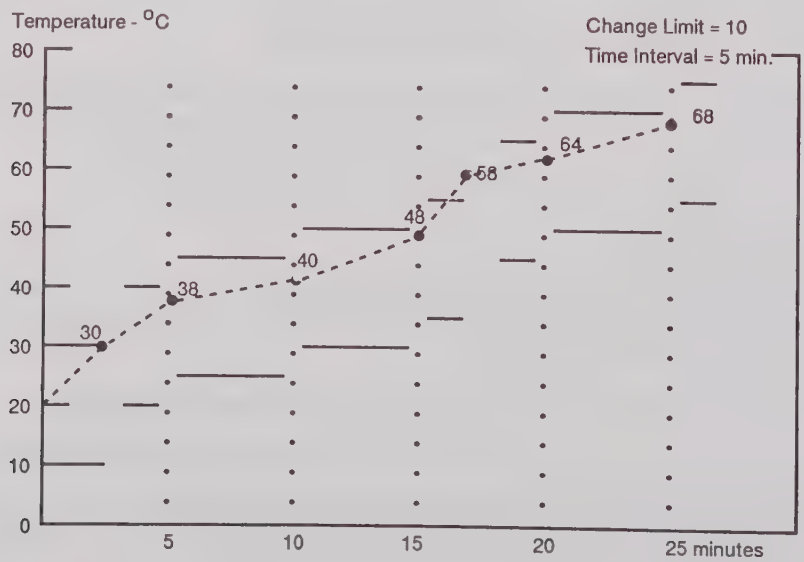


Figure 7-1. Sample Rate-of-Change Limit

7.3 LIMIT OP-CODES

A limit operation code (limit op-code) is a six-digit number that controls the action Digi 4 Plus takes when channel output data goes out of limit or returns within limit, goes open circuit or over-range and returns from open circuit or over-range. Table 7-1 on the following page lists the limit op-codes.

When Digi 4 Plus compares a limit to channel output data, the data is either valid or invalid. Open circuit or over-range data causes invalid output. All other output is valid. Valid data can exceed an assigned limit.

Comparing a limit to channel output data results in a normal, limit exceeded or invalid state.

Normal indicates a valid input within limits, a nulled limit, or the logic bit specified in Limit Op-Code 1 is false.

Limit Exceeded indicates a valid input outside the limit.

Invalid indicates open circuit or over-range channel output.

Digi 4 Plus monitors the state of each limit, looking for a transition from one state to another. This transition can be either a trip or a return.

Trip is a transition to limit exceeded or invalid.

Return is a transition to normal.

Figure 7-2 shows the transitions as Digi 4 Plus monitors limits.

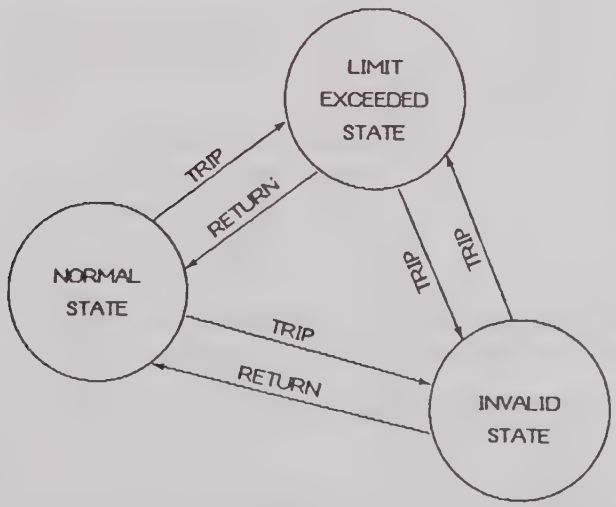


Figure 7-2. How Digi 4 Plus Monitors Limits

Table 7-1. Limit Op-Codes

	Digit 1	Digit 2	Digit 3	Digit 4	Digit 5	Digit 6
Op-Code 1	Address whose logic bit must also be TRUE for a trip to occur at this channel 000 = always TRUE address			1 = message on LIMIT EXCEEDED 0 = message on LIMIT EXCEEDED or INVALID DATA	1 = double scan trip 0 = single scan trip	HYSTERESIS 0 = 10 counts 1 = 1 count . . 9 = 9 counts
Op-Code 2	ACTION TAKEN WHEN LIMIT EXCEEDED			ACTION TAKEN WHEN DATA INVALID		
	1 = activate RELAY 0 = no action	1 = activate ALARM limit indicators 0 = no action	1 = turn ON channel logic bit 0 = no action	1 = activate RELAY 0 = no action	1 = activate ALARM limit indicators 0 = no action	1 = turn ON channel logic bit 0 = no action
Op-Code 3	LIMIT RELAY ADDRESS 01-48 00 = no relay action		LIMIT MESSAGE ADDRESS 01-99 00 = no message		RETURN MESSAGE ADDRESS 01-99 00 = no message	

On a trip, Digi 4 Plus can issue a trip message. During a trip, Digi 4 Plus can:

- o Activate a relay
- o Activate a channel alarm
- o Activate a channel logic bit

On a return, Digi 4 Plus can issue a return message. (Digi 4 Plus does not issue a return message for a rate-of-change limit on a transition from limit exceeded to normal. It does issue a return message on a transition from invalid to normal.)

While a channel is normal, Digi 4 Plus can:

- o Turn off the alarm and channel logic bit
- o Turn off the relay logic bit if no other limit is activating that relay address

7.3.1 Limit Op-Code 1

Limit Op-Code 1 can:

- o Specify a logic address whose logic bit must be true for a trip to occur
- o Control the issuing of messages
- o Set the limit for a single or double scan
- o Specify the hysteresis count

Figure 7-3 shows the digits that control these actions.

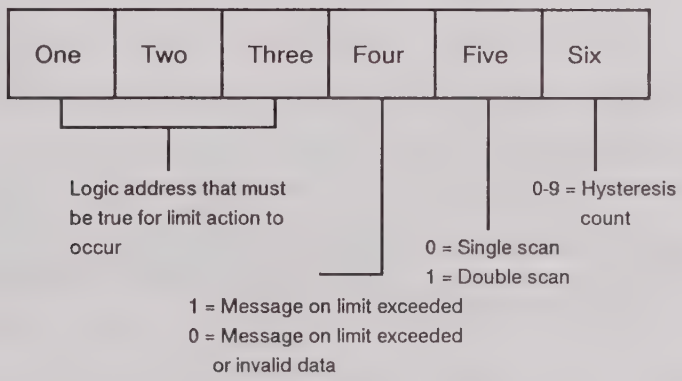


Figure 7-3. Limit Op-Code 1

Digits 1, 2 and 3 specify a logic address whose logic bit must be true for a trip to occur. If you do not assign a value, the logic address defaults to 000 (always true.)

If the logic bit turns false, the limit returns to normal even if the channel output data exceeds its limit.

Digit 4 controls the issuing of messages. 0 = trip messages when the output data exceeds the limit or channel output data is open or over-range; return messages when displayed data is no longer open or over-range or a reading returns within limits. 1 = messages only when channel output data exceeds the limit and returns within limits; no trip or return messages if channel output data goes into or returns from an invalid state.

Digit 5 specifies the scan. 0 = single scan (Digi 4 Plus requires only one scan to initiate a trip or return). 1 = double scan (Digi 4 Plus waits for two successive scans before

initiating a trip or return). On a transition from normal, the two successive readings do not have to be the same type. One limit exceeded reading followed by an invalid reading, or vice versa, initiates a trip.

Channel output data is not considered normal until two successive readings are within limits. The limit minus the hysteresis count determines the limit bounds. (See Digit 6.)

Digit 6 specifies the hysteresis counts. If channel output data goes out-of-limit, the hysteresis count controls its return within bounds. You can specify a hysteresis count from 0 to 9; 0 specifies 10 counts (default). For example, a count of 6 means that channel output data has to be 6 counts within the assigned limit to clear the trip. If you select double scan, Digi 4 Plus waits for two successive readings that are 6 counts within the limit. You do not specify a hysteresis count for a rate-of-change limit.

Digi 4 Plus applies the hysteresis count to the least significant digit. For example, if channel output data exceeds a high trip limit of 12.45 and you specify a hysteresis count of 6, Digi 4 Plus waits until the output data falls below 12.39 before returning from limit exceeded. If you select double scan, it waits until two successive readings fall below 12.39.

Example: Assign the following values to Limit Op-Code 1 at Channel 311:

Digit 1	Digit 2	Digit 3	Digit 4	Digit 5	Digit 6
2	1	5	1	1	5

Digi 4 Plus:

- o Waits until the logic bit at Channel 215 is true before enabling a trip at this channel
- o Returns to normal when the logic bit at Channel 215 is false
- o Issues trip and return messages when a reading goes out of or returns within limits
- o Waits for double scan verification before initiating a trip or return
- o Waits until two successive readings of channel output data return 5 counts within the limit before issuing a return from limit exceeded

7.3.2 Limit Op-Code 2

Limit Op-Code 2 can:

- o Turn on a relay logic bit
- o Turn on the alarm (limit indicator and beeper)
  and/or
- o Turn on the channel logic bit

Figure 7-4 shows the digits that control these actions.

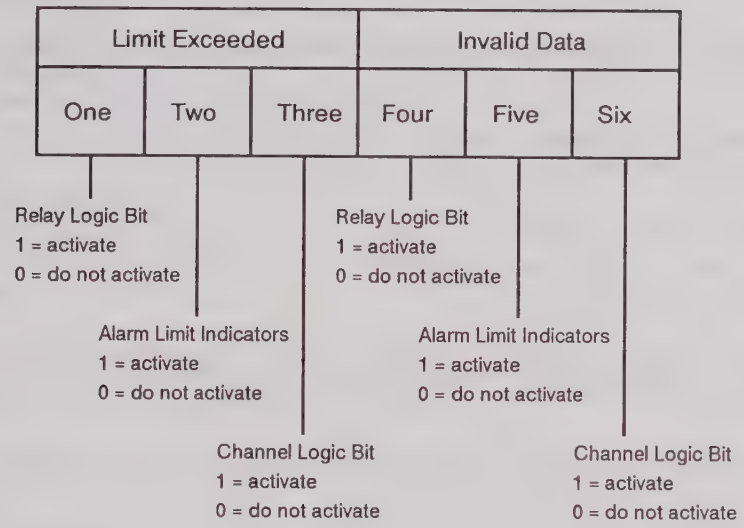


Figure 7-4. Limit Op-Code 2

We call these relay, alarm and logic bit digits R A L R A L where:

R = Relay
A = Alarm
L = Logic bit

(RALRAL does not appear in the display; it is a mnemonic to help you assign values to Limit Op-Code 2.)

If you assign a 1 to any digit in Limit Op-Code 2, this means you want Digi 4 Plus to perform the specified action when a trip occurs.

Relay (Digit 1 and Digit 4)

Digit 1 = 1. Digi 4 Plus activates the relay assigned in Limit Op-Code 3 when channel output data exceeds the assigned limit.

Digit 4 = 1. Digi 4 Plus activates the relay assigned in Limit Op-Code 3 when channel output data is invalid.

(Relay = 1 doesn't mean the relay is active; it means the relay <u>is activated</u> during a trip.

Alarm (Digit 2 and Digit 5)

When channel data exceeds its limit or becomes invalid, Digi 4 Plus can automatically activate the following alarm indicators:

- The beeper (Press any key on the operator panel to silence it)
- The word ALARM in the trip message (NORM in return message)
- The asterisk following the data
- The letter A before the channel address in the upper display
- System alarm LED

Digit 2 = 1. Digi 4 Plus activates the alarm indicators when channel output data exceeds the limit.

Digit 5 = 1. Digi 4 Plus activates the alarm indicators when channel output data is invalid.

Only channels with alarm indicators enabled can be included in an alarm status report. See Section 9 for more information.

(Alarm = 1 doesn't mean a limit alarm is active; it means a limit alarm is activated when a trip occurs.)

Channel Logic Bit (Digit 3 and Digit 6)

Digit 3 = 1. Digi 4 Plus activates the channel logic bit when channel output data exceeds the limit.

Digit 6 = 1. Digi 4 Plus activates the channel logic bit when channel output data is invalid.

(Logic = 1 doesn't mean that the channel logic bit is active; it means that the channel logic bit is activated when a trip occurs.

7.3.3 Limit Op-Code 3

Limit Op-Code 3 can:

- Specify a relay address
- Specify a limit message address
- Specify a return message address

Figure 7-5 shows the digits that control these actions.

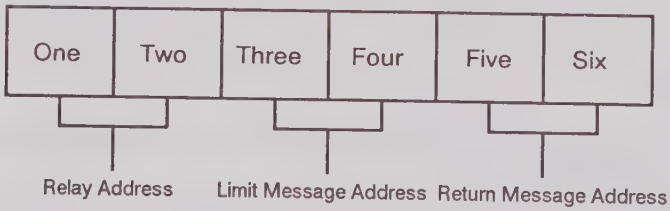


Figure 7-5. Limit Op-Code 3

Digits 1 and 2 specify a relay address (01-48). A relay is activated when a trip occurs if Digit 1 or Digit 4 of Limit Op-Code 2 = 1. The default is 00 (no relay activated).

Digits 3 and 4 specify the address (01-99) of a message that is output when a limit is exceeded or data is open or over-range. The default is 00 (no limit message output). A relay does not have to be activated to print a trip message.

Digits 5 and 6 specify the address (01-99) of a message that is output when data returns within limits. The default is 00 (no return message output).

See Section 8 for more information.

7.4 RELAYS

Digi 4 Plus has:

- o Forty-eight logical relays (Kaye Relay Closure modules provide up to 48 physical relays outputs)
- o Two master relays (odd and even)
- o One watch dog relay

7.4.1 Logical Relays

Relay Addresses 01-48 correspond to Logic Addresses 001-048. A relay logic bit can be activated when a limit trips.

Logical relays are always set for static operation. When a limit trips, a relay logic bit is turned on if you assign a non-zero relay address in Limit Op-Code 3 and specify relay logic bit activation in Limit OP-Code 2.

Because you can assign the same relay address to multiple limits, one or more trips can activate a relay. If a trip clears one limit, it is not always turned off, because several limits may have the same relay address. In Figure 7-6, notice that Relay 09 is turned on if a trip occurs at Channel Address 201, 202 or 203. It is not turned off until limits at Channels 210, 202 and 203 are all normal.

Example: A trip at Limit 1, Channel 201; Limit 2, Channel 202 or Limit 1, Channel 203 activates Relay 09 and sets Logic Bit 009 true. Relay 09 does not turn off until all three limits are no longer tripped. When it turns off, the logic bit at Logic Address 009 is false.

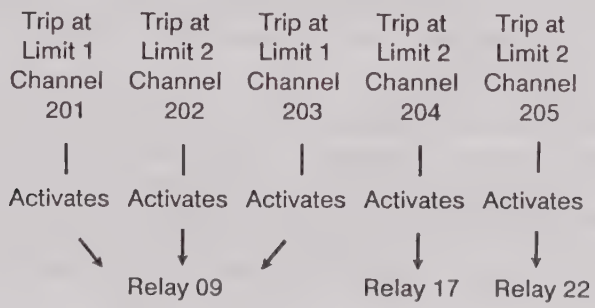


Figure 7-6. Trip Action

Function 150 (sequencer) can also turn on relays. Plan relay mapping so you don't assign the same relay address for two distinct and possible conflicting purposes.

Configuration Code Addresses 101-148 designate latching relays. Latching relays are not zeroed if a power outage occurs. Instead, they remember the state of their logic bit before power-down.

7.4.2 Master Relays

Digi 4 Plus has output terminals for the odd and even master relays. The master relay connections provide each relay with normally open (NO) and normally closed (NC) outputs for turning external devices on or off. Outputs from these relays can control the operation of resistive load devices whose voltages do not exceed 48 VDC.

Master relay action depends upon assigned limits and op-codes. Digi 4 Plus checks all limits every math scan to see if any call for master relay action. If they do, a normally de-energized relay receives power and a normally energized relay loses it.

Configuration Code Address 007 controls master relays. Digit 1 controls the odd master relay; Digit 2 controls the even master relay. Digit 3 specifies normally energized or normally de-energized operation. The default is normally de-energized.

You can configure one master relay for momentary pulse or static operation, one for static and the other for momentary pulse operation or both for the same operation. When a trip occurs, a master relay can be activated for static or pulse operation.

Static Operation

A trip controls static operation; a trip exists when channel output data is exceeded or invalid. We use the term MRELAY when a static master relay is activated. MRELAY is active as long as one or more limits is tripped and its assigned relay is activated.

To configure a master relay for static operation, assign a non-zero relay address (Limit Op-Code 3) and specify relay action (Limit Op-Code 2).

Momentary Pulse Operation

A master trip or master pulse governs momentary pulse operation. A master trip (MTRIP) is a limit trip with an active relay and alarm. A master return (MRETURN) usually occurs when channel data returns within limits. It may also occur on limit exceeded/invalid or invalid/limit exceeded transitions if specified (Limit Op-Code 2).

When a master relay is activated, the corresponding logic bit is turned on. The odd master relay controls the logic bit at Logic Address 049; the even master relay controls the logic bit at Logic Address 050.

To configure a master relay for momentary pulse operation, assign a non-zero relay address (Limit Op-Code 3) and specify relay <u>and</u> limit alarm action (Limit Op-Code 2).

Table 7-2 lists Digits 1 and 2 of Configuration Code Address 007.

Table 7-2. Digits 1 and 2 of Configuration Code Address 007

Digit 1	Odd Master Relay
0	Activated when MRELAY[1] occurs at a limit with an odd relay address (default)
1	Pulsed when MTRIP[2] occurs at a limit with an odd relay address
2	Pulsed when MRETURN[3] occurs at a limit with an odd relay address
3	Pulsed when MTRIP or MRETURN occurs at a limit with an odd relay address
4	Activated when MRELAY exists at a limit with a non-zero relay address
5	Pulsed when MTRIP occurs at a limit with a non-zero relay address
6	Pulsed when MRETURN occurs at a limit with a non-zero relay address
7	Pulsed when MTRIP or MRETURN occurs at a limit with a non-zero relay address

1. MRELAY means the limit is tripped and the assigned relay is activated.
2. MTRIP means the limit makes a transition from normal to limit exceeded or invalid and the assigned relay and alarm are activated.
3. MRETURN means the relay and alarm are no longer activated.

Digit 2 Even Master Relay

0 Activated when MRELAY[4] exists at any limit with an even relay address (default)
1 Pulsed when MTRIP[5] occurs at a limit with an even relay address
2 Pulsed when MRETURN[6] occurs at a limit with an even relay address
3 Pulsed when MTRIP or MRETURN occurs at a limit with an even relay address
4 Activated when MRELAY exists at a limit with a non-zero relay address
5 Pulsed when MTRIP occurs at a limit with a non-zero relay address
6 Pulsed when MRETURN occurs at a limit with a non-zero relay address
7 Pulsed when MTRIP or MRETURN occurs at a limit with a non-zero relay address

7.4.3 Watchdog Relay

The Digi 4 Plus also has a terminal for the watchdog relay. The watchdog relay is tied to a continuously running system diagnostic routine and provides NO and NC contacts. If power fails or the Digi 4 Plus microprocessor malfunctions, the relay can enable backup controls, set alarms or shut down the process.

The NO contact opens if the Digi 4 Plus malfunctions; the NC contact closes if there is a malfunction.

7.4.4 Optional Physical Relays

Digi 4 Plus can drive up to 48 external relays with the solid state or mechanical relay closures. Solid state relays are available in the Quad Relay module (V2715), which is controlled by the D4 Output Driver, or the Solid State Relay Closure (SSRC-8). Electro-mechanical relays are available in the electromechanical relay output unit (RC-8R).

A relay closure has 8 relay outputs. Connect them directly to Digi 4 Plus or, by adding an RD-48 relay driver, you can locate them up to 1000 feet from Digi 4 Plus.

The Quad Relay module accommodates up to 4 solid state relays. The Solid State Relay Closure accommodates up to 8 solid state relays. Four voltage types are available for both types of solid state modules: 120 VAC, 60 VDC, 240 VAC and 200 VDC (all normally open).

Solid state relays eliminate contact arcing and interference and should be used for switching inductive loads.

The electromechanical relay has three states: normally open, normally closed and latched. The relays are rated for 2 amp, 250 VAC and 3 amp, 30 VDC. Each relay has an LED display; the LED indicator goes on when a relay is energized.

See Section 2 and the documentation supplied with your relay closure for more information.

---

4. MRELAY means the limit is tripped and the assigned relay is activated.
5. MTRIP means the limit makes a transition from normal to limit exceeded or invalid and the assigned relay and alarm are activated.
6. MRETURN means the relay and alarm are no longer activated

SECTION 8 - MESSAGES AND LABELS

8.1 GENERAL INFORMATION 8-1

8.2 ANSWER-BACK MESSAGE 8-2

8.3 MULTI-PURPOSE MESSAGES 8-3
- 8.3.1 Limit Messages 8-3
- 8.3.2 Sequencer Messages 8-4
- 8.3.3 Header Messages 8-4
- 8.3.4 Auto-Dial Telephone Numbers. 8-4
- 8.3.5 Start Text and End Text Messages 8-4

8.4 CHANNEL LABELS 8-6

8.1 GENERAL INFORMATION

Messages and labels provide a textual description of displayed data.

Messages can:

- o Describe the limit action at a channel address
- o Provide report header information
- o Describe sequencer operation
- o Specify telephone numbers for auto-dial reporting
- o Indicate start text and end text messages
- o Provide an answer-back message for a computer

Labels describe the displayed data at a channel address.

You assign a message or label to a text address. Table 8-1 lists the message address, text address and message type.

Table 8-1. Text Addresses

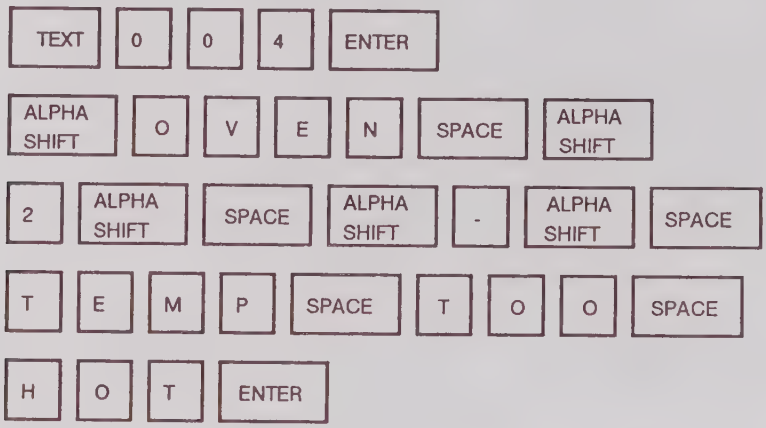
Message Address	Text Address	Message Type
00	000	32-character answer-back message sent in response to an access command from the communications port's CXT protocol
01-99	001-099	32-character messages that include: Limit messages Report headers Sequencer messages Auto-dial telephone numbers Start text and end text messages
101-816	101-816	8-character channel labels that describe channel output data

To assign a message or label:

- o Press the TEXT key. The upper display contains the last text address accessed. The lower and alphanumeric display are blank.
- o Key in the text address, or press the INCREMENT or DECREMENT key to access the address.
- o Press the ENTER key. The alphanumeric display contains the first character in the message. It is blank if you have not entered text. The lower display contains 01.

As you key in each character, it appears in the alphanumeric display and the number in the lower display increments by 1. When the value in the lower display equals the maximum number of characters (8 or 32), Digi 4 Plus automatically returns to 01. After you key in the characters, press the ENTER key. Digi 4 Plus automatically leaves the alpha shift mode when you press the ENTER key.

For example, to assign the message OVEN 2 - TEMP TOO HOT to Text Address 004, key in:



To review a message or label character-by-character at the operator panel, press the INCREMENT or DECREMENT key in non-alpha shift mode. To obtain a list of Messages 01 to 99, request a list program.

You can even change your mind while entering a message or label. Simply press the TEXT key and enter the text address. Then press the NULL key to clear the display so you can define a new message. If you decide not to change the text halfway through the new entry, press the RESTORE key to restore the previous message. If you press both the NULL and ENTER keys, you cannot restore a message or label.

Configuration Code Addresses 061 to 063 control the output and buffering of messages.

Configuration Code Address 061 controls the buffering of limit and sequencer messages. Digi 4 Plus can output them immediately or hold them in the text output buffer. Messages are buffered in the same way as reports.

Configuration Code Address 062 specifies the maximum number of messages stored in the text output buffer. The default is 99. This guarantees that messages are always output even if Digi 4 Plus generates multiple messages during the same math scan. Configuration Code Address 062 also specifies the output device and whether the oldest message is deleted when buffer contains the maximum number. As a default, Digi 4 Plus automatically sends messages to Printer Port 1.

Configuration Code Address 063 specifies the message address that contains telephone numbers for automatic transmission of limit and sequencer messages. It also specifies the message address of optional start-of-text and end-of-text messages.

See Section 10 for more information.

8.2 ANSWER-BACK MESSAGE (00)

Message 00 is a 32-character answer-back message, used with communications port CXT protocol. It identifies the source of data transmitted to a computer and is sent in response to Access Command 000. Text Address 000 stores one answer-back message per unit. See Section 11 for more information.

8.3 MULTI-PURPOSE MESSAGES (01-99)

Messages 01 to 99 can specify the contents and format of trend reports, describe limit action or steps in the sequencer function, appear in a report header, provide start-of-text and end-of-text messages and store auto-dial telephone numbers.

Text Addresses 001 to 099 store Messages 01 to 99. We suggest partitioning message addresses into meaningful groups so one message does not serve dual purposes. For example, dedicate Messages 01-30 for limit descriptors, Messages 31-59 for sequencer descriptors, messages 60-80 for Auto-Trend and Messages 81-99 for report headers.

8.3.1 Limit Messages

A limit message indicates when channel data exceeds limits or becomes invalid (open or over-range) and when data returns within the limits or becomes valid. Use Limit Op-Code 3 to assign the message addresses. (You can assign the same message address to more than one limit.)

A Limit Message shows:

- o The date/time channel data exceeded the limit or became invalid
- o The word LIMIT or ALARM

  As a default, the word LIMIT appears in the message when the channel data exceeds its limit or becomes invalid. However, if the alarm indicators are configured, (Limit Op-code 2, Digits 2 and/or 5 equal to 1), the word ALARM appears in the message. An asterisk follows the data.
- o The channel address and label
- o The channel output data or, for invalid data, the words OPEN or OVER-RANGE
- o Your personalized message

Example:

04/20/86	13:37:02	LIMIT	104	ZONE-4	132.9*	OVEN NO.1 OUT OF SPEC
Date	Time		Channel Address	Channel Label	Data	User-defined Message

A Return Message shows:

- o The date/time channel data returned within limit or became valid
- o The word RETURN or NORM

  As a default, the word RETURN appears in the message when the channel data returns within limit or becomes valid. However, if the alarm indicators are configured, (Limit Op-code 2, Digits 2 and/or 5 equal to 1), the word NORM appears in the message.
- o The channel address and label
- o The channel output data
- o Your personalized message

Example:

04/20/86	13:41:29	RETURN	104	ZONE-4	125.0	OVEN NO.1 WITHIN SPEC
Date	Time		Channel Address	Channel Label	Data	User-defined Message

8.3.2 Sequencer Messages

A sequencer message describes a step in the sequencer or prompts an operator to perform a task. You can specify a message address for each step in the sequencer and assign it to the corresponding sequencer configuration code.

8.3.3 Header Messages

A header message contains the information that appears in report headers. A header can have up to nine lines. Each header line has 64 or 128 characters. Headers are stored at consecutive message addresses.

Configuration Code Addresses 014, 024, 034 and 044 format headers for Data Reports 1, 2, 3 and 4, respectively. Configuration Code Address 054 formats the header for the alarm status report. See Section 9 for more information.

8.3.4 Auto-Dial Telephone Numbers (Optional Modem Equipment)

An Auto-dial message contains one or two telephone numbers that Digi 4 Plus calls to transmit reports, messages and/or accumulation totals to your printer or terminal. Simply assign your telephone numbers to a message address.

Digi 4 Plus can make local and long distance calls to United States and/or Canadian telephones numbers. If Digi 4 Plus can't reach the first number, it calls the second. When the transmission is complete, Digi 4 Plus hangs up. See Section 11 for more information.

8.3.5 Start Text and End Text Messages

Start text (STX) and end text (ETX) messages specify the beginning and end of data reports, alarm status reports, messages and accumulation totals. An STX message for a data report or alarm status report precedes the header (if defined). Assign the address of the STX and ETX messages to configuration code addresses.

Configuration Code Address	Contains STX and ETX Message Addresses for
013	Data Report 1
023	Data Report 2
033	Data Report 3
043	Data Report 4
053	Alarm Status Report
063	Messages
073	Accumulation totals

STX and ETX messages can include alphanumeric data or control characters, such as line feeds and form feeds. You enter STX and ETX messages in hexadecimal digits that represent ASCII characters. Table 8-2 list hexadecimal digits and ASCII character equivalents. An STX or ETX message can contain up to 32 hexadecimal digits, which correspond to 16 ASCII characters.

The STX message below shows hexadecimal digits and equivalent ASCII characters. Notice that two hexadecimal digits represent one ASCII character. This message contains the phrase STATION 1, a carriage return (CR) and a line feed (LF). It is configured to precede Data Report 1.

01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	...	...	...	...	...	...	32
5	3	5	4	4	1	5	4	4	9	4	F	4	E	2	0	0	D	0	A								
S	T	A	T	I	O	N		SP	1			CR				LF											

Table 8-2. Hexadecimal/ASCII Character Equivalents

00	NUL	20	SP	40	@	60	\
01	SOH	21	!	41	A	61	a
02	STX	22	"	42	B	62	b
03	ETX	23	#	43	C	63	c
04	EOT	24	$	44	D	64	d
05	ENQ	25	%	45	E	65	e
06	ACK	26	&	46	F	66	f
07	BEL	27	'	47	G	67	g
08	BS	28	(	48	H	68	h
09	HT	29	)	49	I	69	i
0A	LF	2A	*	4A	J	6A	j
0B	VT	2B	+	4B	K	6B	k
0C	FF	2C	‘	4C	L	6C	l
0D	CR	2D	-	4D	M	6D	m
0E	SO	2E	.	4E	N	6E	n
0F	SI	2F	/	4F	O	6F	o
10	DLE	30	0	50	P	70	p
11	DC1 (X-ON)	31	1	51	Q	71	q
12	DC2 (TAPE)	32	2	52	R	72	r
13	DC3 (X-OFF)	33	3	53	S	73	s
14	DC4 ~~(TAPE)~~	34	4	54	T	74	t
15	NAK	35	5	55	U	75	u
16	SYN	36	6	56	V	76	v
17	ETB	37	7	57	W	77	w
18	CAN	38	8	58	X	78	x
19	EM	39	9	59	Y	79	y
1A	SUB	3A	:	5A	Z	7A	z
1B	ESC	3B	;	5B	[	7B	{
1C	FS	3C	<	5C	\	7C	|
1D	GS	3D	=	5D	]	7D	} (ALT MODE)
1E	RS	3E	>	5E	∧ (↑)	7E	~
1F	US	3F	?	5F	— (←)	7F	DEL (RUB OUT)

8.4 CHANNEL LABELS

A channel label identifies channel output data. It can contain up to eight characters. Assign channel labels to Text Addresses 101-816 so the text address of the label corresponds to the channel address it identifies. For example, enter the label that appears with data at Channel 116 to Text Address 116.

A label can be on the same line or the line above channel output data. Configuration Code Addresses 016, 026, 036 and 046 control the placement in Data Reports 1, 2, 3 and 4, respectively. Configuration Code Address 056 controls the placement of labels in alarm status reports. Labels can also be part of a limit message, sequencer message or accumulation total.

Examples:

501 TEMP1 50.00 502 TEMP2 12.50 503 TEMP3 12.50 504 TEMP4 12.50
505 PRESS1 12.50 506 PRESS2 12.50

A label on the same line as channel output data.

501	502	503	504	505	506
TEMP1	TEMP2	TEMP3	TEMP4	PRESS1	PRESS2
50.00	12.50	12.50	12.50	12.50	12.50

A label on the line above channel output data.

SECTION 9 - REPORTS

9.1 GENERAL INFORMATION 9-1

9.2 REPORT GENERATION 9-2

9.3 REPORT FORMATS 9-3
- 9.3.1 Headers 9-3
- 9.3.2 Body 9-4
- 9.3.3 Sample Reports 9-6

9.4 TEXT OUTPUT BUFFER 9-9

9.1 GENERAL INFORMATION

A report is a record of system output data. Digi 4 Plus can generate 4 independent data reports and 1 alarm status report.

Each data report can include a header, channel (but not CALC channel) data, the logic states of relays and status inputs and historical buffer data. You can also configure data reports to supply the database for Kaye software packages or as a trend report. See the documentation supplied with your software packages or Auto-Trending for more information.

The alarm status report contains data from all channels in alarm. It can also include a header and the logic states of relays and status inputs.

The following configuration codes specify when a report is generated, where it is output and its content and format:

Configuration Code Addresses	Controls
010 to 017	Data Report 1
020 to 027	Data Report 2
030 to 037	Data Report 3
040 to 047	Data Report 4
050 to 056	Alarm Status Report

When you initialize the system, Data Report 1 is configured with the following defaults:

- It is sent to the printer port when you press the LOG key.
- It includes data from Channel Addresses 101 to 116. Channels are formatted 16 per line.
- It includes the logic states of relays and status inputs.

The false/true transition of a logic bit generates a report. You assign the address of this logic bit to a configuration code.

If you assign the logic address that corresponds to the LOG key or ALARM LOG key to the controlling configuration code address, you can generate a report by pressing the LOG key or ALARM LOG key.

Digi 4 Plus can send reports to the printer port and/or communications port. The printer port of a Digistrip 4 Plus is dedicated to the internal printer. The printer port of a Digi-Link 4 Plus can transmit data to a CRT or a local printer. The communications port has two mutually exclusive protocols, terminal and computer, for communication with a terminal, printer or CRT.

Digi 4 Plus can also hold a user-specified number of reports in a temporary storage area called the text output buffer. It can also transmit reports via telephone to a remote printer or terminal.

See Section 6 for more information on logic addresses, Section 9 for more information on configuration code addresses and Section 11 for more information on the communications port.

9.2 REPORT GENERATION

Digi 4 Plus generates a report when a user-specified logic bit makes a false/true transition. For example, when a system timer resets, its logic bit goes from false to true. This transition can generate a report if you assign the address of the system timer logic bit to the appropriate configuration code.

The following configuration code addresses control report generation:

Configuration Code Address	Controls
010	Data Report 1
020	Data Report 2
030	Data Report 3
040	Data Report 4
050	Alarm Status Report

Each configuration code has two three-digit numbers. Digits 1, 2 and 3 specify a logic address. When the logic bit at that address makes a false/true transition, Digi 4 Plus generates a data report if AUTO LOG is active (or an alarm status report if ALARM LOG is active). Digits 4, 5 and 6 also specify a logic address. When the logic bit at this address makes a false/true transition, Digi 4 Plus unconditionally generates the report. (If it generates a report during a program listing, the report is not output until the listing is complete.)

Digit 1	Digit 2	Digit 3	Digit 4	Digit 5	Digit 6
Logic address that generates data report (AUTO/ALARM LOG active)			Logic address that generates data report		

The default value for Configuration Code Address 010 is 000091. The LOG key controls the logic bit at Logic Address 091. When you press it, this logic bit makes a false/true transition and generates Data Report 1.

The default value for Configuration Code Addresses 020, 030, 040 and 050 is 000000. Since the logic bit at Logic Address 000 is always true, it cannot generate a report. You must assign a non-zero logic address (other than 099) to the appropriate configuration code address to generate Data Report 2, 3, 4 or the alarm status report.

<u>Example</u>: Assign 905091 to Configuration Code Address 020.

System Timer 05 controls Logic Address 905. At reset, the logic bit at Logic Address 905 makes a false/true transition. If AUTO LOG is enabled, Digi 4 Plus generates Data Report 2. If it is not enabled, Digi 4 Plus does not generate Data Report 2.

The LOG key controls Logic Address 091. When you press the LOG key, Digi 4 Plus generates Data Report 2.

9.3 REPORT FORMATS

Each report has two parts: the header and the body.

You can also include start text (STX) and end text (ETX) messages for each report. They can contain alphanumeric data or control characters such as line feeds and form feeds. Assign the address of the start text and end text message to one of the following configuration code addresses:

Configuration Code Address	Contains STX and ETX Message Addresses for
013	Data Report 1
023	Data Report 2
033	Data Report 3
043	Data Report 4
053	Alarm Status Report

9.3.1 Headers

You can define a header for each report type. Headers are printed at the top of a page after a form feed. Successive reports of that type on the same page do not have a header; reports of a different type do.

The following configuration code addresses specify the format and content of the header:

Configuration Code Address	Formats Header of
014	Data Report 1
024	Data Report 2
034	Data Report 3
044	Data Report 4
054	Alarm Status Report

A header can have up to nine lines of information; for example, company name, plant site, and process information. In Auto-Trend, each header line defines a graph.

A header line contains 64 or 128 characters. You enter the header information at text addresses. Each text address contains up to 32 alphanumeric characters. With the 64 character format, each line has two user-defined messages. With the 128 character format, each line has four user-defined messages.

Header messages must be at consecutive text addresses. You specify the address of the first header message. Based on this address, the number of lines in the header and the number of characters per line, Digi 4 Plus determines the addresses of additional header messages For example, if you configure a report to contain a three-line header with 128 characters per line, the header contains 12 messages, four per line. If you select 010 as the first text address, Digi 4 Plus includes the data at Text Addresses 010 through 021 in the header. If you do not assign text to an address, it inserts 32 blank spaces.

The header can also contain a 16-channel numeric header (01-16). The numbers 01 to 16 are printed across the page with the 16 channel per line format.

9.3.2 Body

The following configuration code addresses specify the format and content of the body of a report:

Configuration Code Addresses	Format the Body of
015, 016, 017	Data Report 1
025, 026, 027	Data Report 2
035, 036, 037	Data Report 3
045, 046, 047	Data Report 4
055, 056	Alarm Status Report

The first line of a report contains the date/time it was generated. The body of a report can also include:

- o A user-defined message after the date/time
- o Output from up to 128 channels. Channels are formatted 1, 2, 3, 4, 5, 6, 7, 8, 9 or 16 per line
- o Channel addresses, either on the same line as the output data or on the line above
- o Channel labels, either on the same line as the output data or on the line above
- o Extra spaces between channels (0, 1, 2, 3, 4, 5, 6, 7, 8 or 9)
- o The logic states of the relays and status inputs
- o Data from up to 16 historical buffers (data reports only)

Message on the Date/Time Line

Configuration Code Addresses 015, 025, 035, 045 or 055 let you specify the text address of a user-defined message (up to 32 characters) that follows the date/time.

Channels

A channel is allocated a fixed number of characters:

Channel address (optional)	= 4 characters (3 digits and a space)
Label (optional)	= 9 characters (8 alphanumeric characters and a space)
Channel output data	= 6 characters (5 digits with a decimal point or minus sign; or 4 digits with decimal point and minus sign)
Units	= 1 alphanumeric character
Alarm indicator	= 1 character (An asterisk indicates an alarm)

Configuration Code Addresses 015, 025, 035, 045 and 055 specify the number of channels per line and the number of spaces between channels. Configuration Code Addresses 016, 026, 036, 046 and 056 specify the placement of channel addresses and labels.

With an 8 or 16 channel per line format, you cannot place channel addresses and labels on the same line as the output data. Place them on the line above the channel output data (and Digi 4 Plus inserts a blank line after each line of channel output data).

Digi 4 Plus automatically includes channel addresses in the alarm status report. If you specify channel addresses for a data report, only data from channels assigned a non-zero function code appears in the report. If you do not specify channel addresses, the report includes all channels; blank space indicates channels assigned Function Code 000 (skip function).

You can configure a report so Digi 4 Plus adds blank spaces between channels. The number of extra spaces depends upon the characters per line and the placement of the channel address and label. For example, suppose a report is sent to a printer that can format 137 characters per line. If you select the 8 channel per line format and place channel addresses and labels on the line above the data, each channel requires 8 characters.

Channel data	=	6	Units = 1
Alarm asterisk	=	1	
		8	

8 channels x 8 characters per channel = 64 characters per line. 137 - 64 = 73 extra spaces per line. Format up to 9 extra spaces between channels.

Relays and Status Inputs

Configuration Code Addresses 016, 026, 036 and 046 format relays and status inputs in a report. If you include the logic states of relays and status inputs, they appear on two lines. A value of 0 indicates the logic bit is false. A value of 1 indicates the logic bit is true.

Historical Buffers

Configuration Code Addresses 017, 027, 037, 047 select historical buffer data.

A data report can include samples from up to 16 historical buffers. (The alarm status report does not include historical buffer samples.) A line of information specific to each historical buffer precedes the data. It contains the address of the historical buffer, the address, label and current reading of the channel from which the samples are taken and the logic address that controls the time interval between samples. Samples are formatted 16 per line with a 128-character header or 8 per line with a 64-character per line header.

Report Length

Configuration Code Addresses 015, 025, 035, 045 and 055 control the number of lines in a report. If you do not specify the length, Digi 4 Plus does not issue a form feed and, on non-Kaye printers, data may be printed on a page perforation.

New Page

Configuration Code Addresses 014, 024, 034, 044 and 054 control the new page feature. When Digi 4 Plus releases a report to a printer, it checks to see if you configured the report to begin on a new page when the previous report is a different type.

If you configured the report to begin on a new page, it issues a form feed, the printer moves to the top of the next page, outputs the header (if specified) and the report. If you did not configure the report to begin on a new page, it compares the number of lines in the report to the number of lines remaining.

When the number of report lines is fewer than or equal to the number of lines remaining, Digi 4 Plus outputs the report on that page. If you specified a header, it is output when the previous report on that page is a different type. When the number of report lines is greater than the number of lines remaining, it issues a form feed, moves to the top of the next page, outputs a header (if specified) and the report.

If a report has fewer lines than specified, Digi 4 Plus inserts blank lines. If it reaches the bottom of the page while filling in blank lines, Digi 4 Plus ends the report there. It does not advance to the next page until another report is generated.

If a report has more lines than specified, Digi 4 Plus includes them, but page control may not operate properly. For example, if you specify 20 lines in a report and it contains 26 lines, Digi 4 Plus includes the extra lines. When this occurs near the end of a page, no form feed is issued and, on non-Kaye printers, data may be printed on a page perforation.

9.3.3 Sample Reports

The following pages contain sample reports and applicable configuration codes. Use them to design your own formats.

```
EMPIRE POWER AND LIGHT - GREENWOOD HILLS - GENERATOR 3 BEARING TEMPERATURES
        01      02      03      04      05      06      07      08      09      10      11      12      13      14      15      16
03/27/87 20:35:32 HOURLY REPORT
100  119.6F  119.3F  116.3F  117.8F  118.0F  121.1F  120.6F  119.8F  120.6F  118.3F  122.8F  118.6F  120.0F  122.5F  120.1F  124.9F*
200  114.0F  122.4F  122.5F  120.3F  122.9F  121.3F  122.4F  124.1F  121.3F  124.1F  122.3F  120.5F  122.6F  122.3F  119.1F  118.3F
300  120.3F  121.2F  122.9F  122.4F  122.9F  122.3F  121.6F  117.4F  122.6F  121.7F  122.6F  122.9F  114.9F  118.8F  122.6F  124.6F
400  122.6F  122.4F  122.6F  118.8F  122.4F  122.4F  122.6F  123.6F  124.6F  122.9F  122.8F  121.5F  121.3F  121.3F  122.8F  120.3F
RELAYS: 00001000  00000000  00001000  00000000 STATUS: 00000000  00000000  00000000  00000000
BUFFER # 04  SOURCE 301  TEMP A  119.9  TRIGGER 091
 119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9  117.9  115.5  114.7
 116.5  114.9  118.4  118.4  118.4  118.4  118.4  116.5  116.5  116.5  115.9  115.9  115.9  115.9  115.9  115.9
```

Configuration Code Address	Configuration Code	Formats
014	001211	128 characters per header line 1 line header 01-16 numeric header First header messages stored at Message Address 12
015	121400	12 lines in body of report (11 lines of data plus final blank line) 16 channels per line Message on line with date/time Hourly report stored at Message Address 14
016	017770	Data from Rows 100 to 600 Logic states of relays and status inputs No channel addresses or labels
017	010000	Data from Historical Buffer 04 included

Figure 9-1. Sample Data Report 1

EMPIRE POWER AND LIGHT - PEARL BEACH
GENERATOR 8 BEARING TEMPERATURES
03/27/87 20:30:03 CRITICAL REPORT

101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A	TEMP A
118.9F	119.3F	116.3F	117.6F	118.0F	121.1F	120.6F	119.8F*	120.6F	118.3F	122.8F	118.6F	120.0F	122.5F	120.1F	121.9F*
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216
TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B	TEMP B
114.8F	118.3F	122.5F	120.3F	122.9F	121.3F	122.4F	1224.1F	121.8F	121.1F*	122.3F	120.5F	122.6F	122.3F	119.1F	118.3F
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316
TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C	TEMP C
120.8F	121.3F	122.7F	122.4F	122.7F	121.1F	117.4F	119.8F*	121.8F	124.2F	122.3F	124.6F	114.9F	122.9F	122.3F*	124.6F

BUFFER # 04 SOURCE 301 TEMP A 119.9 TRIGGER 091

119.9	119.9	119.9	119.9	119.9	119.9	119.9	119.9
119.9	119.9	119.9	119.9	119.9	117.9	115.5	114.7
116.5	114.9	118.4	118.4	118.4	118.4	118.4	116.5
116.5	116.5	115.9	115.9	115.9	115.9	115.9	115.9

Configuration Code Address	Configuration Code	Formats
024	011220	64 characters per header line 2 line header First header messages stored at Message Address 12
025	191500	19 lines in body of report (15 lines of data plus 4 blank lines) 16 channels per line Message on line with date/time Critical report stored at Message Address 15
026	707000	Data from Rows 100 to 300 Channel addresses and labels included
027	010000	Data from Historical Buffer 04 included

Figure 9-2. Sample Data Report 2

3/27/87 20:44:29 DAILY REPORT

101	102	103	104	105	106	107	108
119.9F	119.3F	116.3F	117.6F	118.0F	121.1F	120.6F	119.8F*
109	110	111	112	113	114	115	116
120.6F	118.3F	122.8F	118.6F	120.0F	122.5F	120.1F	121.9F
201	202	203	204	205	206	207	208
124.6F	122.4F	122.5F	122.9F	120.3F	121.3F	122.4F	124.1F
209	210	211	212	213	214	215	216
121.8F	124.4F*	122.3F	120.5F	122.6F	122.3F	119.1F	118.3F

Configuration Code Address	Configuration Code	Formats
034	000000	No header
035	131680	13 lines of body of report (9 lines of data plus 4 blank lines) 8 channels per line Message on line with date/time Daily report stored at Message Address 16
036	503000	Data from Rows 100 to 200 Channel addresses on line above data
037	000000	No historical buffer data

Figure 9-3. Sample Data Report 3

```
CLINCO PHARMACEUTICAL CO STERILIZATION UNIT 1267
TEMP MONITORING BATCH 163
03/27/87  20:35:05  DAILY REPORT
101  TEMP A   119.9F   102  TEMP A   119.3F   103  TEMP A   116.3F   104  TEMP A   117.6F
105  TEMP A   118.0F   106  TEMP A   121.7F   107  TEMP A   120.4F   108  TEMP A   119.6F*
109  TEMP A   120.6F   110  TEMP A   118.3F   111  TEMP A   122.8F   112  TEMP A   118.6F
113  TEMP A   120.0F   114  TEMP A   122.5F   115  TEMP A   122.9F   116  TEMP A   121.3F
301  TEMP C   120.6F   302  TEMP C   121.2F   303  TEMP C   122.9F   304  TEMP C   122.4F
305  TEMP C   122.9F   306  TEMP C   121.5F   307  TEMP C   121.3F   308  TEMP C   117.4F
309  TEMP C   122.6F   310  TEMP C   124.7F   311  TEMP C   121.5F   312  TEMP C   120.4F
313  TEMP C   114.9F   314  TEMP C   122.9F   315  TEMP C   122.3F   316  TEMP C   124.6F
BUFFER # 04 SOURCE 101 TEMP A   119.9, TRIGGER 091
     119.9  119.9  119.9  119.9  119.9  119.9  119.9  119.9
     119.9  119.9  119.9  119.9  119.9  117.9  115.5  114.7
     116.5  114.9  118.4  118.4  118.4  118.4  118.4  116.5
     116.5  116.5  115.9  115.9  115.9  115.9  115.9  115.9
```

Configuration Code Address	Configuration Code	Formats
044	112420	64 characters per header line 2 line header First header messages stored at Message Address 12 Start report at top of page if previous report on page not Report 3
045	151640	19 lines in body of report (15 lines of data plus 4 blank lines) 4 channels per line Message on line with date/time Daily report stored at Message Address 16
046	607000	Data from Rows 100 to 300 Channel addresses and labels precede channel data
047	010000	Data from Historical Buffer 04 included

Figure 9-4. Sample Data Report 4

```
03/27/87  20:50:19  CHANNEL ALARM
105  118.0F*  111   122.8F*  210  124.4F*  315  122.3F*

03/27/87  20:51:12  CHANNEL ALARM
105  118.0F*  111   122.8F*  210  124.4F*  315  122.3F*

03/27/87  20:55:11  CHANNEL ALARM
105  118.0F*  111   122.8F*  210  124.4F*  315  122.3F*
```

Configuration Code Address	Configuration Code	Formats
054	000000	No header
055	073260	7 lines of body of report (6 lines of data plus final blank line)* 6 channels per line
056	000000	Channel addresses automatically precede channel data

* To determine the number of lines in an alarm status report, divide the number of channels that could go into alarm by the number of channels formatted per line.

Figure 9-5. Sample Alarm Status Report

9.4 TEXT OUTPUT BUFFER

The text output buffer is a storage area that holds data reports, alarm status reports, messages and accumulation totals. The printer port and the communications port share the buffer.

Data reports and alarm status reports are generated when a user-specified logic bit makes a false/true transition. Messages are generated by limit action and/or the sequencer function. Accumulation totals are generated at the end of each accumulation interval. After a report, message or accumulation total is generated, Digi 4 Plus sends it to the text output buffer.

You must specify the following:

- The maximum number of a given data type stored in the buffer at one time
- The action taken if the maximum number of a data type is already in the buffer
- The output device (printer port or communications port)
- The conditions release data from the buffer

The following configuration code addresses specify the maximum number and delete oldest parameters. If you do not define the maximum number, the text output buffer holds only one issue of the corresponding data type. As a default, Digi 4 Plus does not delete the oldest copy of a given data type. These configuration code addresses also specify the output device for reports and messages. Digi 4 Plus can output reports, messages and accumulation totals to the printer port and/or the communications port. The accumulation function defines the output device for accumulation totals.

Configuration Code Address	Specifies Maximum Size/ Delete Oldest Feature for
012	Data Report 1
022	Data Report 2
032	Data Report 3
042	Data Report 4
052	Alarm Status Report
062	Messages
072	Accumulation Totals

The maximum number and delete oldest features define a fixed size first-in, first-out (FIFO) buffer. If you enable the delete oldest feature and the maximum number is reached, Digi 4 Plus deletes the oldest report of that type when it generates a new one. If you disable the delete oldest feature and the maximum number is reached, the buffer stores the next report of that type and Digi 4 Plus forces a release of that type. If another issue of that type arrives while the maximum plus 1 (MAX + 1) is in the buffer, it is not stored.

If Digi 4 Plus generates another accumulation total while buffer has the maximum number plus 1 (MAX + 1), it is held in channel memory until there is enough room in the buffer. The channel holds only the most recent accumulation total (one for each accumulation function).

A user-specified logic bit forces the release of data from the text output buffer. Use the following configuration code addresses to specify two release sources, one for each output device.

Configuration Code Address	Controls Release of
011	Data Report 1
021	Data Report 2
031	Data Report 3
041	Data Report 4
051	Alarm Status Report
061	Messages
071	Accumulation Totals

The first three digits specify the logic address that controls printer port release; the second three digits specify the logic address that controls communications port release. When the logic bit is false, the text output buffer holds that data type. When the logic bit is true, it releases the data. If the logic bit turns false before the data is released, the buffer releases data until it is empty.

Digit 1	Digit 2	Digit 3	Digit 4	Digit 5	Digit 6
.		.	.		.
. . . . .			. . . . .		
	.			.	
	.			.	

Logic address that releases buffered data to Printer Port 1

Logic address that releases buffered data to Communications Port

The default value for buffer release is 000. The logic bit at Logic Address 000 is always true.

Example: Company XYZ has a Digi 4 Plus at each of its field pumping stations. Data Report 1 is generated each hour and contains information specific to the individual station. Because an operator at each station must perform certain actions based on this data, Data Report 1 must be printed locally as soon as it is generated. The supervisor in the main pump house does not need an hourly report. He wants a set of hourly reports, one from each field station, at the end of the 8-hour shift.

To satisfy both requirements, Data Report 1 is configured for output to both the printer port and the communications port. Logic Bit 000 (always true) releases Data Report 1 to the printer as soon as it is generated.

A system timer with an eight-hour time interval controls the logic bit that releases Data Report 1 to the communications port. The maximum number of Report 1's is defined as 8. Data Report 1 enters the text output buffer hourly. When the system timer resets at the end of eight hours, its logic bit is true, releasing all eight issues from the buffer to the communications port.

The text output buffer can also maintain a recent history of output data. For example, suppose the supervisor wants a set of hourly reports only if a limit is exceeded at a channel address. The maximum number of Report 1's is defined as 8, the delete oldest feature is enabled and the channel address is specified as the buffer release. When a new Data Report 1 enters the buffer, the oldest issue is deleted. This allows the system to maintain an eight hour history for each pumping station. A set of eight hourly reports is transmitted when the release logic bit is true.

The text output buffer can hold 8192 bytes of data. It can store 8189 bytes of user-specified data; 3 bytes are reserved. Each report, message and accumulation total requires the following amount of memory:

Data Report. A base of 34 bytes plus 48 bytes per row of channel data, 96 bytes per historical buffer and 10 bytes if it includes relay and status input information.

Alarm Status Report. A base of 24 bytes plus 4 bytes per channel in alarm and 10 bytes if it includes relay and status input information.

Message or Accumulation Total. 15 bytes.

Define the maximum number of bytes for each report, message and accumulation total so when all maximums are reached, they do not exceed the 8192 byte limit. If there is not enough memory to store a report, message or accumulation total, an overflow occurs and data can be lost.

An overflow forces a printout and/or transmission of data that filled the memory. For example, if an alarm status report fills the allocated memory, Digi 4 Plus outputs all alarm status reports in the text output buffer. To avoid an overflow, use Table 9-1 on at the end of this section to calculate the total number of bytes stored.

Function Code 199 checks the number of bytes in the buffer. If you assign it to a channel and specify Source 1 and Source 2 as 000, the channel displays the number of bytes in the buffer. You can also assign a limit value (for example 8000) so you are notified before the number of bytes reaches 8189.

If the buffer releases more than one data type at once, Digi 4 Plus uses the following priority to determine servicing to the printer port or to the communications port.

1. Limit and sequencer messages
2. Accumulation totals
3. Alarm status report
4. Data Report 1
5. Data Report 2
6. Data Report 3
7. Data Report 4

Digi 4 Plus outputs one issue of a data type, checks if there are data types with higher priorities for output to the same device and outputs the one with the highest priority.

The output device must service data faster than it enters the text output buffer or data can be lost. For example, suppose Digi 4 Plus sends Data Report 1 to a printer that outputs 60 lines per minute and the delete oldest feature is not enabled. If Data Report 1 contains 40 lines, the printer needs 40 seconds to output the report. If Digi 4 Plus generates the report every 30 seconds, the printer cannot output the reports fast enough. The buffer fills (MAX + 1) and data is lost.

The sum of the data rates should not exceed the rate at which an output device can service data. For example, suppose you are buffering messages, accumulation totals, alarm status reports, Data Report 1 and Data Report 2 and that data enters the text output buffer at the following rates:

Messages	1 line per minute
Accumulation totals	1 line per minute
Alarm status report	2 lines per minute
Data Report 1	40 lines per minute
Data Report 2	20 lines per minute

The output device must service the data at 64 lines per minute or the Data Report 2 buffer becomes full and some reports are lost.

If Digi 4 Plus outputs a report to a terminal, the baud rate of the terminal must be faster than the rate at which the data enters the buffer. For example, a terminal that operates at 4800 baud can service 480 characters per second. A line of data can contain up to 137 characters. TRM protocol can service all data types if the total character rate at which data enters the buffer does not exceed the communications port baud rate divided by ten.

Table 9-1. Bytes in Text Output Buffer

	Data Report 1	Data Report 2	Data Report 3	Data Report 4	Alarm Status Report	Messages	Accum. Total
Base value, if data type generated[1]	34	34	34	34	24	15	15
Number of rows x 48[2]					—	—	—
Maximum number of channels in alarm x 4	—	—	—	—		—	—
Number of historical buffers x 96					—	—	—
If relay and status included, add 10						—	—
Number of bytes per report, message or accum. total (add column)							
Maximum number + 1 (MAX + 1)							
Number of bytes per data type = (MAX + 1) x bytes per report, message or accum. total							

Total = 3 bytes plus the sum of total bytes for each data type.
Total should not exceed 8192 bytes.

1. If data type is not generated, total bytes for that data type is 0.
2. Data can come from Row 100, 200, 300 ...700 and/or 800. Each row requires 48 bytes.

SECTION 10 - CONFIGURATION CODES

10.1 GENERAL INFORMATION 10-1

10.2 SYSTEM CONFIGURATION CODES 10-2
- Scanner Mapping (001) 10-5
- Scanner Mapping (002) 10-7
- Peripheral Ports (003) 10-8
- Printer Port (004) 10-10
- Communications Port (005) 10-11
- European Formats (006) 10-12
- Master Relays (007) 10-13
- Security (009) 10-14
- Data Report Configuration Codes (010-047) 10-16
  - Generate Report (010, 020, 030 and 040) 10-17
  - Release Buffered Reports (011, 021, 031, and 041) 10-18
  - Define Buffering/Output Device (012, 022, 032 and 042) 10-19
  - Auto-Dial, STX, EXT (013, 023, 033 and 043) 10-20
  - Format Header (014, 024, 034 and 044) 10-21
  - Format Report (015, 025, 035 and 045) 10-22
  - Select Data (016, 026, 036 and 046) 10-24
  - Select Historical Buffer (017, 027, 037, and 047) 10-26
- Alarm Status Report Configuration Codes (050-056) 10-28
  - Generate Report (050) 10-29
  - Release Buffered Reports (051) 10-30
  - Define Buffering/Output Device (052) 10-31
  - Auto-Dial, STX, ETX (053) 10-32
  - Format Header (054) 10-33
  - Format Report (055) 10-34
  - Select Data (056) 10-36
- Message Configuration Codes 061-063 10-37
  - Release Buffered Reports (061) 10-38
  - Define Buffering/Output Device (062) 10-39
  - Auto-Dial, STX, ETX (063) 10-40
- Accumulation Total Configuration Codes (071-073) 10-41
  - Release Buffered Totals (071) 10-42
  - Define Buffering/Output Device (072) 10-43
  - Auto-Dial, STX, ETX (073) 10-44
- Programming Mode Password (901) 10-45
- CXT Mode Password (902) 10-46

10.3 RELAY LATCHING CONFIGURATION CODES 101-148 10-47

10.4 SEQUENCER CONFIGURATION CODES 201-299 10-48

10.1 GENERAL INFORMATION

A configuration code is a user-defined, six-digit value that tells the system how to perform certain operations. A configuration code address stores the configuration code. There are three groups of configuration codes:

System configuration codes (001-073 and 901-902) specify the global parameters for Digi 4 Plus operation, the contents and format of reports, the output device for reports and messages, and user-defined passwords.

Relay latching configuration codes (101-148) specify which relays are latched at power-up.

Sequencer configuration codes (201-299) specify sequencer operation.

The system must be in the PROGRAM mode to assign configuration codes.

Before beginning, we recommend making copies of the Configuration Code Programming Forms. These forms facilitate data entry and provide a record of assignments.

10.2 SYSTEM CONFIGURATION CODES

System configuration codes specify:

- o Scanner mapping
- o Relay operation
- o Security
- o Selection and format of reports, messages and accumulation totals

When Digi 4 Plus is initialized, system configuration codes are assigned default values. The default is usually zero, although certain codes have non-zero defaults so Digi 4 Plus can perform meaningful operations after initialization:

- o Analog inputs connected to Bank #1 are assigned to Scanner #1 (Configuration Code Address 001).
- o The printer page has 48 lines (Configuration Code Address 004).
- o Data Report 1 is sent to the printer port when you press the LOG key (Configuration Code Addresses 010 and 012).
- o Data Report 1 contains a numeric header, the date/time, the first row of channel data, and the logic states of relays and status inputs (Configuration Code Addresses 014 and 016).
- o Messages are sent to the printer port; the maximum number of messages stored in the text output buffer is 99 (Configuration Code Address 062.)

Each digit in a configuration code has special significance. It can:

Control a single feature. The feature is enabled when the digit = 1 and disabled when the digit = 0. For example, Digit 2 of Configuration Code Address 016 includes the logic states of relays and status inputs in Data Report 1. If Digit 2 = 1, they are included; if Digit 2 = 0, they are not.

Control multiple features. You select the features from a table of options. Each numbered column contains one or more dots that indicate the features are enabled if you assign the number at the top of the column.

Suppose you want to configure your system so an operator must be in the Program mode to assign values to the source, input and output parameters. Digit 3 of Configuration Code Address 009 controls these features. Column 7 contains a dot for secure sources, secure input parameter and secure output parameter. To Program mode protect these parameters, assign a 7.

Digit 3 Configuration Code Address 009

0	1	2	3	4	5	6	7	
	o		o		o		o	Secure SOURCES
		o	o			o	o	Secure INPUT parameters
				o	o	o	o	Secure OUTPUT parameters
o								None of the above

Represent a specific value (0-9). Assign that value to the digit. For example, Digit 5 of Configuration Code Address 014 specifies the number of header lines in Data Report 1. If the header contains 8 lines, assign an 8.

If the value of the digit does not directly reflect your selection, we provide a table to determine the correct value. For example, Digit 5 of Configuration Code Address 015 specifies the number of channels per line in Data Report 1. There is a direct correlation between the values 1 to 9 and the number of channels. However, if Digit 5 = 0, the format is 16 channels per line.

Digit 5 Configuration Code Address 015

0	1	2	3	4	5	6	7	8	9	
o										Format 16 channels per line
	o									Format 1 channel per line
		o								Format 2 channels per line
			o							Format 3 channels per line
				o						Format 4 channels per line
					o					Format 5 channels per line
						o				Format 6 channels per line
							o			Format 7 channels per line
								o		Format 8 channels per line
									o	Format 9 channels per line

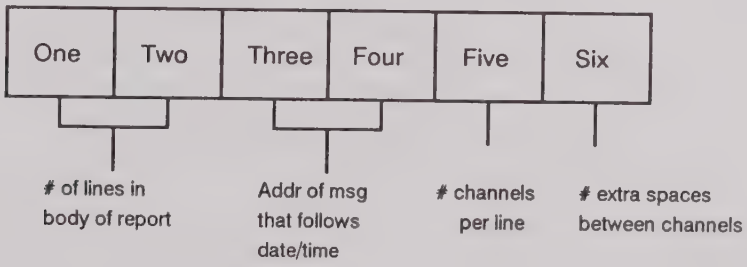
Some digits are grouped together to form two-digit or three-digit entries.

A two-digit entry can:

- o Specify a message address
- o Represent a specific value (00-99); i.e., the number of lines in a data report

For example, Digits 1, 2 of Configuration Code Address 015 specify the number of lines in the data report; Digits 3 and 4 specify the address of the message that follows the date/time.

Configuration Code Address 015

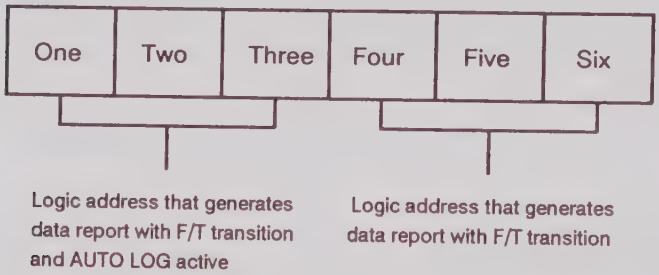


A three-digit entry specifies a logic address. The logic bit at this address can control:

- o Report generation
- o Report output
- o Message output
- o Accumulation totals output

For example, Digits 1, 2, 3 and Digits 4, 5, 6 of Configuration Code Address 010 each specify a logic address that generates a data report.

Configuration Code Address 010



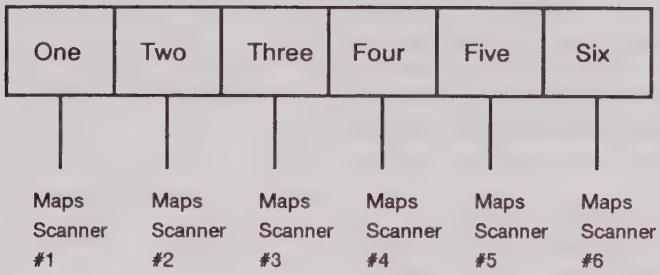
To assign values to a configuration code address:

- o Press the PROGRAM key. (If necessary, key in your password.) Press the ENTER key.
- o Press the CONFIG CODE key. The upper display contains the address of the last configuration code accessed. The lower display is blank. The alphanumeric display contains a C (configuration code).
- o Key in the configuration code address, or press the INCREMENT or DECREMENT key to access the address. Press the ENTER Key. The lower display contains the values assigned to the configuration code address.
- o Key in the configuration code and press the ENTER key.

The following pages describe configuration code addresses. The Digi 4 Plus Quick Reference also contains configuration code address tables.

Configuration Code Address 001

Purpose: Directs system input data from an Analog Plus or RTD Plus scanner (1-6) to a specific row of channel addresses.



You can attach up to 128 analog inputs to a Digi 4 Plus. Each Digi 4 Plus supports up to eight Analog Plus and/or RTD Plus scanners. Each scanner accepts 16 analog inputs. (Configuration Code Address 002 maps scanners 7 and 8.)

Do not assign data from more than one scanner to the same row of channel addresses. For example, if you send data from Scanner 1 to Row 400, do not send any other system input data to this row.

Assign a 0 to the digit that corresponds to an inoperative (unused) analog scanner. Digi 4 Plus scans only those input terminals whose channel addresses are programmed with a measurement function code. Unused scanner input terminals do not affect the analog scan time.

If all system inputs are from an external scanner (DS-8, FS-8, or another Digi 4 Plus), assign 0's to Digits 1-6. Do not send data from an external scanner to a row of channel addresses that receives data from a built-in analog scanner. For example, if you assign data from Scanner 1 to Row 300, do not send external scanner data to this row.

Digit 1

0 Scanner #1 not used
1 Input from Scanner #1 to row 100
2 Input from Scanner #1 to row 200
3 Input from Scanner #1 to row 300
4 Input from Scanner #1 to row 400
5 Input from Scanner #1 to row 500
6 Input from Scanner #1 to row 600
7 Input from Scanner #1 to row 700
8 Input from Scanner #1 to row 800

Digit 2

0 Scanner #2 not used
1 Input from Scanner #2 to row 100
2 Input from Scanner #2 to row 200
3 Input from Scanner #2 to row 300
4 Input from Scanner #2 to row 400
5 Input from Scanner #2 to row 500
6 Input from Scanner #2 to row 600
7 Input from Scanner #2 to row 700
8 Input from Scanner #2 to row 800

Digit 3

0 Scanner #3 not used
1 Input from Scanner #3 to row 100
2 Input from Scanner #3 to row 200
3 Input from Scanner #3 to row 300
4 Input from Scanner #3 to row 400
5 Input from Scanner #3 to row 500
6 Input from Scanner #3 to row 600
7 Input from Scanner #3 to row 700
8 Input from Scanner #3 to row 800

Digit 4

0 Scanner #4 not used
1 Input from Scanner #4 to row 100
2 Input from Scanner #4 to row 200
3 Input from Scanner #4 to row 300
4 Input from Scanner #4 to row 400
5 Input from Scanner #4 to row 500
6 Input from Scanner #4 to row 600
7 Input from Scanner #4 to row 700
8 Input from Scanner #4 to row 800

Digit 5

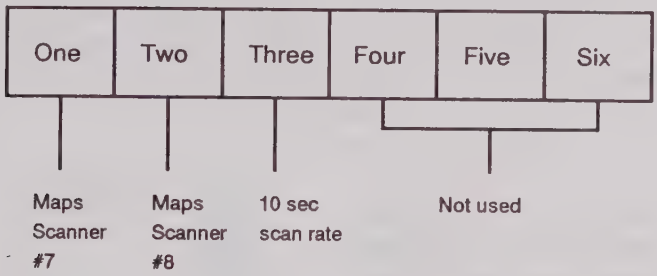
0 Scanner #5 not used
1 Input from Scanner #5 to row 100
2 Input from Scanner #5 to row 200
3 Input from Scanner #5 to row 300
4 Input from Scanner #5 to row 400
5 Input from Scanner #5 to row 500
6 Input from Scanner #5 to row 600
7 Input from Scanner #5 to row 700
8 Input from Scanner #5 to row 800

Digit 6

0 Scanner #6 not used
1 Input from Scanner #6 to row 100
2 Input from Scanner #6 to row 200
3 Input from Scanner #6 to row 300
4 Input from Scanner #6 to row 400
5 Input from Scanner #6 to row 500
6 Input from Scanner #6 to row 600
7 Input from Scanner #6 to row 700
8 Input from Scanner #6 to row 800

Configuration Code Address 002

Purpose: Directs system input data from an Analog Plus or RTD Plus scanner (scanners 7 and 8) to a specific row of channels and synchronizes scanning to a 10 second rate.



Digit 1 directs data from Scanner #7 (Bank 7) to a row of channels.

Digit 2 directs data from Scanner #8 (Bank 8) to a row of channels.

Digit 3 controls the scan rate of local analog inputs.

When Digit 3 = 0, the system continuously scans 40 channels per second at 60 Hz and 33 1/3 channels per second at 50 Hz (with one channel of overhead per scan and one channel of overhead per bank). The scan time depends upon the number of system inputs.

When Digit 3 = 1, the system scans all analog inputs on 10-second time boundaries rather than on a free-running basis. If you do not any analog inputs connected to the Digi 4, but have an external scanner connected, such as the DS-8 or FS-8, assign a 1 to Digit 3.

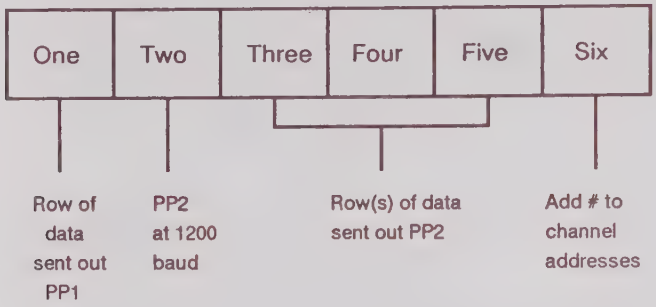
At the end of each analog scan, the logic bit at Logic Address 083 turns momentarily TRUE. To view the time of the analog scan, press the CHANNEL key and access Channel 911. (The display X.XX represents seconds and hundredths of seconds.)

The analog scan rate selected may affect the rate at which Digi 4 Plus checks limits. If you specify second scan in Limit Op-code 1, the system checks the limits at the end of each analog scan. If you have no analog inputs directly connected to the system and selected second scan, we recommend assigning a 1 to Digit 3. The system checks the limits every 10 seconds and channels are updated with new data before the second limit check.

Digits 4, 5 and 6 are not used. Assign 0's.

Configuration Code Address 003

Purpose: Specifies the rows of channel data transmitted via the peripheral ports to a Kaye Analog Output module, Data Display or another Digi 4 Plus. If data is not transmitted to one of these devices, assign a 0 to the corresponding digit.



Use the following tables to determine the value of each digit.

Digit 1 specifies the row of channel data transmitted continuously via Peripheral Port 1 (PP1) to a Kaye Analog Output module or Data Display. Transmission is at 4800 baud.

0	1	2	3	4	5	6	7	8	
	o								Row 100 to peripheral port 1
		o							Row 200 to peripheral port 1
			o						Row 300 to peripheral port 1
				o					Row 400 to peripheral port 1
					o				Row 500 to peripheral port 1
						o			Row 600 to peripheral port 1
							o		Row 700 to peripheral port 1
								o	Row 800 to peripheral port 1
o									None of the above

Digit 2 changes the baud rate of Peripheral Port 2 (PP2) from 2400 to 1200 baud. When digit 2 = 0, Peripheral Port 2 operates at 2400 baud. When digit 2 = 1, Peripheral Port 2 operates at 1200 baud.

Digits 3-5 specify the rows of channel data transmitted in RAMP format. Digi 4 Plus can transmit the data via Peripheral Port 2 to Data Displays and/or another Digi 4 Plus. Transmission is at 2400 baud.

The system automatically transmits rows of channel addresses with the following RAMP channel addresses:

Digi 4 Plus	RAMP
101-116	000-015
201-216	016-031
301-316	032-047
401-416	048-063
501-516	100-115
601-616	116-131
701-716	132-147
801-816	148-163

Digit 3

0	1	2	3	4	5	6	7	
	o		o		o		o	Row 100 to peripheral port 2 in RAMP format
		o	o			o	o	Row 200 to peripheral port 2 in RAMP format
				o	o	o	o	Row 300 to peripheral port 2 in RAMP format
o								None of the above

Digit 4

0	1	2	3	4	5	6	7	
	o		o		o		o	Row 400 to peripheral port 2 in RAMP format
		o	o			o	o	Row 500 to peripheral port 2 in RAMP format
				o	o	o	o	Row 600 to peripheral port 2 in RAMP format
o								None of the above

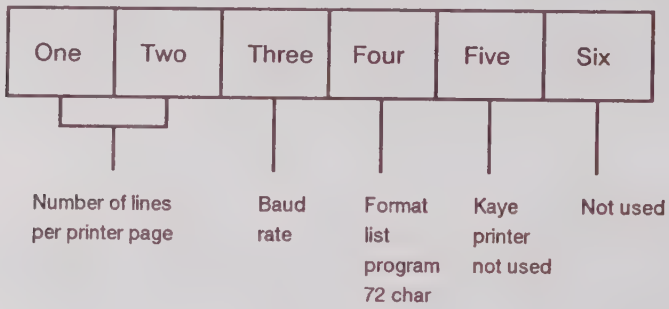
Digit 5

0	1	2	3	
	o		o	Row 700 to peripheral port 2 in RAMP format
		o	o	Row 800 to peripheral port 2 in RAMP format
o				None of the above

Digit 6 specifies the offset added to RAMP channel addresses transmitted via Peripheral Port 2 to another Digi 4 Plus. The data is usually transmitted with the RAMP channel addresses in Digits 3-5 (Digit 6 = 0). However, you can instruct the system to add 100 to RAMP channel addresses 000-063 (Digit 6 = 1).

Configuration Code Address 004

Purpose: Specifies the page format and baud rate of the printer port.



Digits 1-2 specify the number of lines printed before a form feed. The Digistrip 4 Plus built-in printer outputs 48 lines per page. Digits 1 and 2 are automatically set to 48 after initialization. If you use an external printer with Digi-Link 4 Plus, change this value to reflect the number of lines that your printer can output.

Digit 3 specifies the baud rate of the Printer Port. The Digistrip 4 Plus built-in printer operates at 2400 baud (default).

0	1	2	3	4	5	6	7	
o								2400
	o							110
		o						150
			o					300
				o				600
					o			1200
						o		2400
							o	4800

Digit 4 formats a narrower copy for the program listing. When Digit 4 = 1, the system lists the program in a 72-character wide format. When Digit 4 = 0, it lists the program in a 132-character wide format.

Digit 5 signals the system that a Kaye printer is not in use (external printer with Digi-Link 4 Plus only).

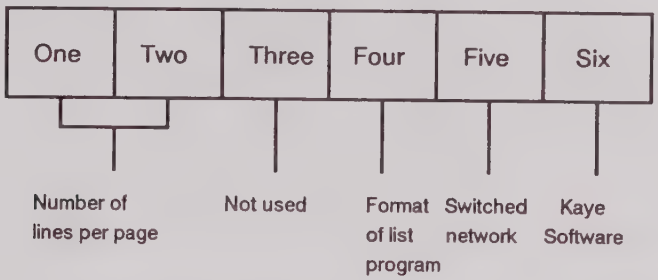
When Digit 5 = 0, an extra blank line is inserted after each report and block of messages/accumulation totals. When Digit 5 = 1, data is transmitted to the printer as required and no extra line feed is inserted.

Set an external printer for even parity. The characters have one start bit, seven data bits, one parity bit (even) and one stop bit (two if the baud rate is 110.)

Digit 6 is not used. Assign a 0.

Configuration Code Address 005

Purpose: Specifies the page format and communications link for the communications port.



Digits 1-2 specify the number of lines transmitted before a form feed (01-99).

Digit 3 is not used. Assign a 0.

Digit 4 formats a narrower copy for a program listing. When Digit 4 = 1, the listing is in 72-character wide format. When Digit 4 = 0, it is in 132-character wide format.

Digit 5 enables switched network support in terminal protocol (TRM) and specifies a 25 second delay between access commands in CXT protocol if the computer access passwords do not match.

TRM protocol

Digit 5 = 0 switched network disabled
Digit 5 = 1 switched network enabled

Switched network support is required for Auto-Dial and KDIAL. If slides 1 and 2 of DIP switch S2 (located on the Data 4 board) are on when the system is initialized, the Digi 4 automatically sets Digit 5 = 1. Slides 1 and 2 specify TRM protocol and modem support.

If slides 1 and 2 were not on when the system was initialized, you can enter a 1 in Digit 5. However, the Digi 4 only reads the changes to this digit at power-up.

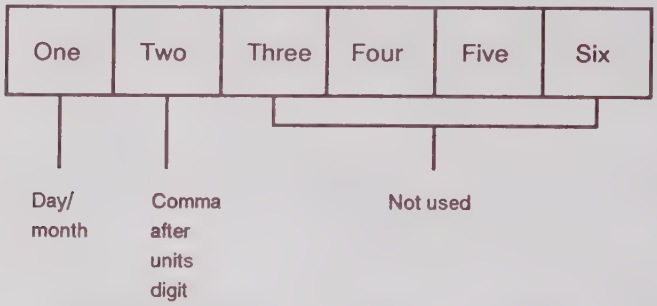
CXT protocol

When Command 91 switches Digi is from TRM to CXT protocol, Digit 5 = 1 enables a 25 second delay between access commands if the computer access passwords do not match. See Configuration Code 902.

Digit 6 defaults to 1. Used with Kaye software interface. Do not change.

Configuration Code 006

Purpose: Specifies the date in a day/month format and includes a comma after the units digit (European format).



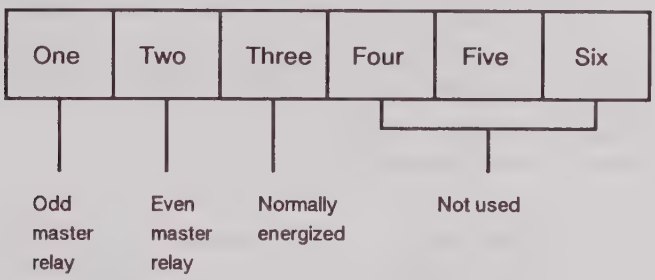
Digit 1 instructs the system to print and transmit the date in a day/month format. For example, when Digit 1 = 0, October 22nd is formatted as 10/22; when Digit 1 = 1, it is formatted as 22/10. Do not select this format if you are generating Auto-Trends.

Digit 2 instructs the system to format data with a comma instead of a decimal point after the units digit. For example, if the Digi 4 Plus operator panel display contains 32.08, when Digit 1 = 0, the printout reads 32.08; when Digit 1 = 1, it reads 32,08.

Digits 3-6 are not used. Assign 0's.

Configuration Code Address 007

Purpose: Specifies master relay operation.



Digits 1-2 configure the master relays for either static operation or momentary pulse. Master relay operation depends upon the assigned limits and their op-codes. You can configure the ODD master relay so it responds only to a limit assigned an odd relay address or configure it to respond to a limit assigned any non-zero relay address. You can configure the EVEN master relay to respond only to a limit assigned an even relay address or configure it to respond to a limit assigned any non-zero relay address.

You do not have to configure Digits 1 and 2 for the same type of relay operation. You can set one relay for static operation and the other to momentary pulse. Or you can set one relay to pulse on an MTRIP and the other to pulse on an MRETURN. (See Section 7 for more information on MRELAY, MTRIP and MRETURN.)

Digit 1

0 Static operation while MRELAY exists at limit with an odd relay address
1 Pulse when MTRIP occurs at limit with an odd relay address
2 Pulse when MRETURN occurs at limit with an odd relay address
3 Pulse when MTRIP or MRETURN occurs at limit with an odd relay address
4 Static operation while MRELAY exists at limit with a non-zero relay address
5 Pulse when MTRIP occurs at limit with a non-zero relay address
6 Pulse when MRETURN occurs at limit with a non-zero relay address
7 Pulse when MTRIP or MRETURN occurs at limit with a non-zero relay address

Digit 2

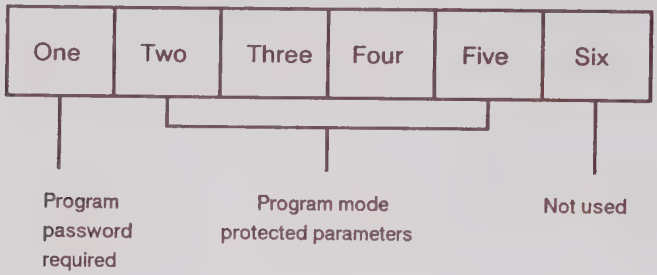
0 Static operation while MRELAY exists at limit with an even relay address
1 Pulse when MTRIP occurs at limit with an even relay address
2 Pulse when MRETURN occurs at limit with an even relay address
3 Pulse when MTRIP or MRETURN occurs at limit with an even relay address
4 Static operation while MRELAY exists at limit with a non-zero relay address
5 Pulse when MTRIP occurs at limit with a non-zero relay address
6 Pulse when MRETURN occurs at limit with a non-zero relay address
7 Pulse when MTRIP or MRETURN occurs at limit with a non-zero relay address

Digit 3 instructs the system to set the two master relays in a normally powered state. (0 = normally de-energized; 1= normally energized)

Digits 4-6 are not used. Assign 0's.

Configuration Code Address 009

Purpose: Specifies whether the Program mode is password protected and additional parameters are secured to the Program mode.



Digit 1 requires a six-digit password to enter the Program mode. Enter 1 to enable this feature. This prevents inadvertent changes to Program mode protected parameters. The programming mode password is stored in Configuration Code Address 901.

As a default, Program mode protected parameters are:

- o Function codes
- o Decimal codes
- o Configuration codes
- o System clock

Digits 2-5 Program mode protect the following parameters:

- o Alarm Log and Auto Log
- o Channel sources, limits, input/output values and units
- o System timers, constant addresses and historical buffers
- o Messages and/or labels (text addresses)

Digit 2

0	1	2	3	4	5	6	7	
	o		o		o		o	Secure ALARM LOG
		o	o			o	o	Secure AUTO LOG
				o	o	o	o	Secure SYSTEM TIMERS
o								None of the above

Digit 3

0	1	2	3	4	5	6	7	
	o		o		o		o	Secure SOURCES
		o	o			o	o	Secure INPUTS
				o	o	o	o	Secure OUTPUTS
o								None of the above

Digit 4

0	1	2	3	4	5	6	7	
	o		o		o		o	Secure UNITS
		o	o			o	o	Secure LIMITS
				o	o	o	o	Secure TEXT
o								None of the above

Digit 5

0	1	2	3	
	o		o	Secure CONSTANTS
		o	o	Secure HISTORICAL BUFFERS
o				None of the above

Digit 6 is not used. Assign a 0.

Configuration Code Addresses 010-047

Configuration Code Addresses 010-047 control the four independent data reports:

- o Configuration Code Addresses 010-017 control Data Report 1.
- o Configuration Code Addresses 020-027 control Data Report 2.
- o Configuration Code Addresses 030-037 control Data Report 3.
- o Configuration Code Addresses 040-047 control Data Report 4.

Configuration code definitions for each report are identical. However, each set of codes controls different data reports. The second digit of the configuration code address indicates the data report type. The third digit indicates the purpose of the configuration code. For example, Configuration Code Addresses 014, 024, 034 and 044 all specify the content and format of the report header. Configuration Code Address 014 specifies the header for Data Report 1; Configuration Code Address 024 specifies the header for Data Report 2 and so on.

A false to true logic transition generates a data report. After reports are generated, they can be output immediately or held in a text output buffer for future output. Digi 4 Plus can also automatically dial user-programmed telephone numbers and transmit data reports.

A data report always contains the date/time it was generated. It can also contain:

- o A descriptive header (up to 9 lines)
- o Data from up to 128 channels
- o Channel addresses and labels
- o Relay and status input information
- o Data from up to 16 historical buffers

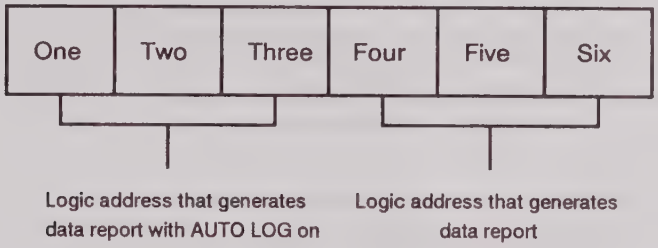
To simplify the report formatting, Data Report 1 is configured with several defaults. It is printed when you press the LOG key and it contains:

- o A numeric header
- o Data from Channel Addresses 101-116
- o 16 channels per line
- o The logic states of the relays and status inputs

You can change the defaults.

Configuration Code Addresses 010, 020, 030 and 040

Purpose: Specify the logic addresses that generate the data report.



Digits 1-3 specify a logic address. When the logic bit at this address makes a FALSE/TRUE transition, the system generates the data report if AUTO LOG is active. To enable AUTO LOG, press the LOG key rapidly twice.

Digits 4-6 specify a logic address. When the logic bit at this address makes a FALSE/TRUE transition, the system unconditionally generates the data report.

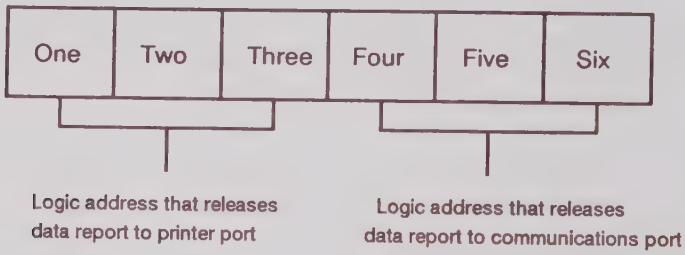
The default value for Configuration Code Address 010 is 000091. The LOG key controls the logic bit at Logic Address 091. When you press the LOG Key, this logic bit makes a FALSE/TRUE transition and generates Data Report 1.

The default value for Configuration Code Addresses 020, 030 and 040 is 000000. The logic bit at Logic Address 000 is always TRUE. Since a data report is generated when a logic bit makes a FALSE/TRUE transition, Logic Address 000 cannot generate a data report. You must assign a non-zero logic address (other than 099).

After the system generates a data report, it can be output immediately or held in the text output buffer. See Section 9 for information on the text output buffer.

Configuration Code Addresses 011, 021, 031, and 041

Purpose: Specify the logic addresses that release data reports stored in the text output buffer.



Digits 1-3 specify a logic address. When the logic bit at this address is TRUE, the system transmits all issues of that report type in the text output buffer that are destined for the printer port, even if the logic bit turns FALSE during transmission.

Digits 4-6 specify a logic address. When the logic bit at this address is TRUE, the system transmits all issues of that report type in the text output buffer that are destined for the communications port, even if the logic bit turns FALSE during transmission.

The default value for these configuration code addresses is 000000. Because the logic bit at Logic Address 000 is always TRUE, the data report type is output as soon as it is generated.

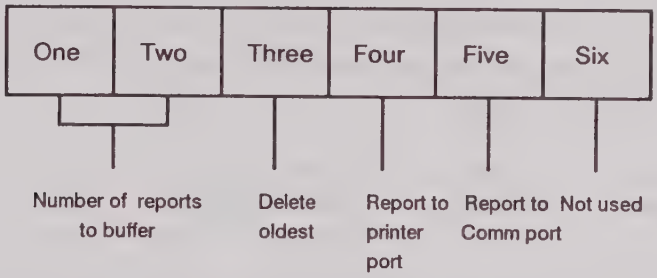
Example: Assign 101907 to Configuration Code Address 021. (Configuration Code Address 021 controls the release of Data Report 2 from the text output buffer.)

Limit action at Channel 101 controls the logic bit at Logic Address 101. While the logic bit at Channel 101 is TRUE, all issues of Data Report 2 are released to the printer port. When it is FALSE, all issues of Data Report 2 are held in the text output buffer. When the logic bit makes a FALSE/TRUE transition, the system releases all reports of that type even if the logic bit turns FALSE during transmission.

System Timer 07 controls the logic bit at Logic Address 907. The logic bit at Logic Address 907 is TRUE immediately after System Timer 07 resets. It is FALSE at all other times. While the logic bit is FALSE, all issues of Data Report 2 are held in the text output buffer. When System Timer 07 resets, the system outputs all reports of that type even if the logic bit turns FALSE during transmission.

Configuration Code Addresses 012, 022, 032 and 042

Purpose: Specify the maximum number of reports of a given type stored in the text output buffer; whether the oldest report is deleted when the buffer contains the maximum number; and the output port.



Digits 1-2 specify the maximum number of a given data report type stored in the text output buffer. For more information on the text output buffer, see Section 9.

When you specify Digits 1 and 2 as 00, the buffer can hold one "extra" report of the corresponding type. If there is not enough memory to store text output, a buffer overflow occurs. A buffer overflow forces output of the data that caused the overflow and data may be lost.

Digit 3 specifies whether the system deletes the oldest report when the buffer contains the maximum number.

Digit 4 instructs the system to send a data report to the printer port. (On a Digistrip 4 Plus, the printer port is dedicated to the built-in printer. On a Digi-Link 4 Plus, it connects to an external printer.)

When Digit 4 = 1, the report is sent to the printer port. When Digit 4 = 0, it is not. Digit 4 defaults to 1 for Configuration Code Address 012; it defaults to 0 for Configuration Code Addresses 022, 032 and 042.

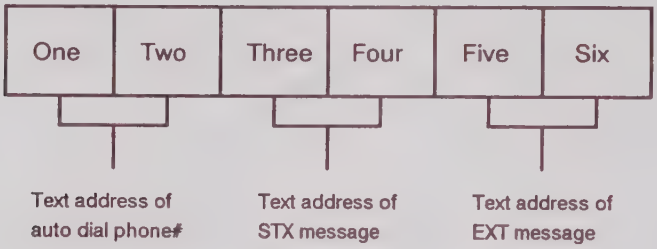
Digit 5 instructs the system to send a data report to the communications port for output to a local or remote printer/terminal or computer. A modem is required for remote transmission.

When Digit 5 = 1, the report is sent to the communications port. When Digit 5 = 0 (default), it is not.

Digit 6 is reserved. Assign a zero.

Configuration Code Addresses 013, 023, 033 and 043

Purpose: Specify the text addresses that contain Auto-Dial telephone numbers, start-of-text messages and end-of-text messages.



Digits 1-2 specify the text address that contains the telephone number for automatic transmission of a data report. See Section 11 for more information on Auto-Dial.

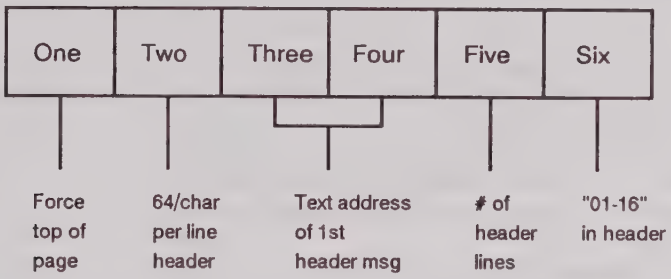
Digits 3-4 specify the text address that contains the start-of-text message. The system automatically outputs this message as part of the first line of the data report.

Digits 5-6 specify the text address that contains the end-of-text message. The system automatically outputs this message as the final line of the data report.

(The communications port CXT protocol does not support start-of-text and end-of-text messages. See Section 11 for more information on CXT protocol.)

Configuration Code Addresses 014, 024, 034 and 044

Purpose: Format data reports so different report types are on separate pages; specify the format and contents of the report header.



Digit 1 specifies the page format for the different report types.

When Digit 1 = 0 (default), different data report types are printed on the same page. When Digit 1 = 1, a data report is printed on a new page if the previous data report is a different type.

Digit 2 specifies a 64-character or 128-character header. Digit 2 = 0 formats 128 characters per header line (default); Digit 2 = 1 formats 64 characters per header line and also affects historical buffer data. See Configuration Code Addresses 017, 027, 037 and 047.

Digits 3-4 specify the text address (01-99) of the first of a group of consecutively addressed header messages.

Digit 5 specifies the number of lines (1-9) in the header.

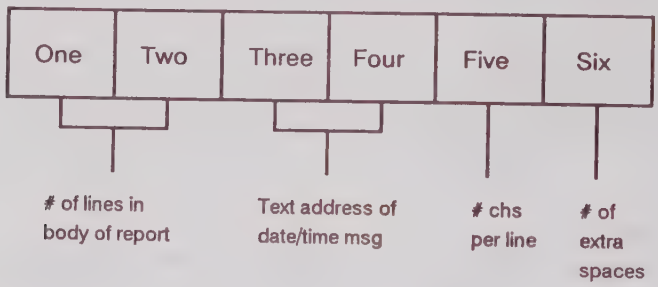
The text address specified in Digits 3 and 4 points to the first header message. The number of characters per line determines the number of consecutively addressed messages on each line.

128-character header. Each line contains four 32-character messages.
64-character header. Each line contains two 32-character messages.

Digit 6 formats a numeric header that follows the header messages. The numeric header contains the numbers 01-16. It is intended for use with the 128-character header and 16 channel per line format.

Configuration Codes Addresses 015, 025, 035 and 045

Purpose: Format the body of the data report.



Digit 1 specify the number of lines in the body of the data report. The system compares the number of lines in the report with the number of lines per page specified in Configuration Code Address 004. If there are not enough lines on a page for the entire report, it begins the report at the top of the next page.

The first line contains the date/time the report was generated. A data report can also contain additional lines, depending upon:

- The rows of channel output data (0-8 lines).
- Placement of channel addresses and labels. (If channel addresses and/or labels are placed above the channel data, the system inserts a blank line after each line of data.)
- The lines of historical buffer data (2 or 3 per historical buffer).
- Whether it includes relay and status input information.

You can format reports to include blank lines after the data to provide more white space between reports. Simply add the number of blank lines to the total number of lines. For example, if Report 1 has 30 lines and you want 5 blank lines to follow it, assign 35 to Digits 1 and 2 of Configuration Code Address 015. (With a Kaye printer, a blank line follows each report.)

Digits 3-4 specify the text address (01-99) of the message on the first line of the data report (after date/time). 00 = no message.

Digit 5 specifies the number of channels per line (default = 0).

A value of 0 specifies the 16 channel per line format when channel ad-dresses are on the line above the output data. A value of 0 specifies the 8 channel per line format when channel addresses are on the same line as the output data. Values of 1-9 specify 1-9 channels per line.

Digit 6 specifies extra spaces between channels. The number depends upon the format.

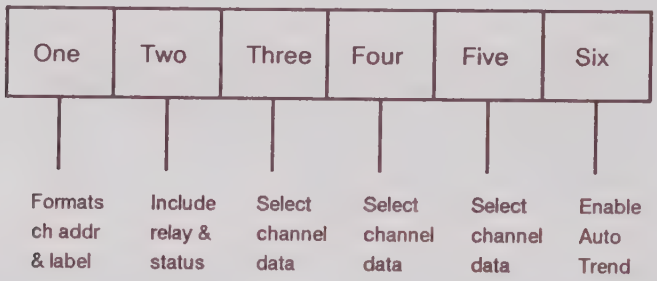
The Kaye printer can output up to 137 characters per line. Each channel is allocated a fixed number of characters.

Channel address	=	4 characters (3 digits and a space)
Label (optional)	=	9 characters (8 alphanumeric characters and a space)
Channel data	=	6 characters (5 digits with decimal point or minus sign; or 4 digits with decimal point and minus sign.)
Units	=	1 alphanumeric character
Alarm signal	=	1 character (* signals an alarm)

Example: With a 5-channel per line format, channel addresses and labels preceding output data, each channel requires 21 characters. The maximum number of characters per line printer is 137. 137 - (5 X 21) = 32. There are 32 extra spaces per line, so you can assign up to 8 extra spaces between channels.

Configuration Code Addresses 016, 026, 036 and 046

Purpose: Format channel addresses and labels; include the logic states of relays and status inputs; select data for the data report.



Digit 1 specifies whether channel addresses and/or labels are included in the report. There are two formats for placing channel addresses and labels: on the same line as the data (default) or on the line above it. In addition to specifying the format of channel addresses and labels, you must configure the system to include them in the report.

If you select a 7, 8, 9 or 16 channel per line format, channel addresses and labels do not fit on the same line as the data. Place them on the line above.

0	1	2	3	4	5	6	7	
			o		o		o	Channel addresses and labels on line above data
		o	o			o	o	Include labels in report
				o	o	o	o	Include channel addresses in report
o	o							None of the above

Digit 2 instructs the system to include the logic states of the 48 relays and 32 status inputs. Relay and status information requires 2 lines and follows channel data.

Digit 2 of Configuration Code Address 016 defaults to 1, which automatically includes the logic states of relays and status inputs in Data Report 1. Digit 2 of Configuration Code Addresses 026, 036 and 046 defaults to 0. The logic states of relays and status inputs are not automatically included in the corresponding data report. To include the logic states, change the value of the digit to 1. They must be included for Auto-Trend.

Digit 3 instructs the system to include output data from channel addresses in Rows 100, 200 and/or 300 in the data report. Digit 3 of Configuration Code Address 016 defaults to 1, which automatically includes data from channels in Row 100 in data report 1.

0	1	2	3	4	5	6	7	
	o		o		o		o	Include row 100 in report
		o	o			o	o	Include row 200 in report
				o	o	o	o	Include row 300 in report
o								None of the above

Digit 4 instructs the system to include output data from channel addresses in Rows 400, 500 and/or 600 in the data report.

0	1	2	3	4	5	6	7	
	o		o		o		o	Include row 400 in report
		o	o			o	o	Include row 500 in report
				o	o	o	o	Include row 600 in report
o								None of the above

Digit 5 instructs the system to include output data from channel addresses in Rows 700 and/or 800 in the data report.

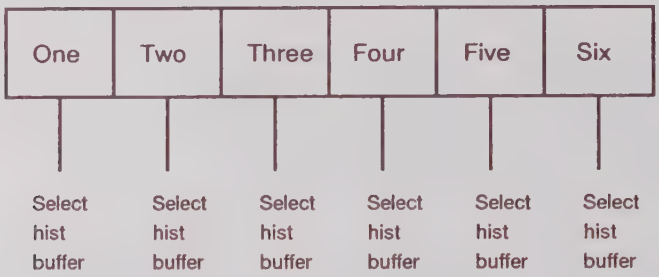
1

0	1	2	3	
	o		o	Include row 700 in report
		o	o	Include row 800 in report
o				None of the above

Digit 6 enables Auto-Trend. See the Auto-Trend Manual (M4118) for more information.

Configuration Code Addresses 017, 027, 037, and 047

Purpose: Instruct the system to include data from the historical buffers in the data report.



The system prints historical buffer data after the channel data. A single line of information that precedes historical buffer data contains:

- o The buffer address
- o The channel address of the input data
- o The label describing the channel output data
- o The most current value of input data
- o The logic address (Source 2) that triggers entry of each sample into the historical buffer

The 32 buffer values are printed 8 or 16 per line. The number of characters in the header determines the number of samples per line. With a 128-character header, samples are formatted 16 per line; with a 64-character header, they are formatted 8 per line.

Digit 1

0	1	2	3	4	5	6	7	
	o		o		o		o	Data from historical buffer 01 in report
		o	o			o	o	Data from historical buffer 02 in report
				o	o	o	o	Data from historical buffer 03 in report
o								None of the above

Digit 2

0	1	2	3	4	5	6	7	
	o		o		o		o	Data from historical buffer 04 in report
		o	o			o	o	Data from historical buffer 05 in report
				o	o	o	o	Data from historical buffer 06 in report
o								None of the above

Digit 3

0	1	2	3	4	5	6	7	
	o		o		o		o	Data from historical buffer 07 in report
		o	o			o	o	Data from historical buffer 08 in report
				o	o	o	o	Data from historical buffer 09 in report
o								None of the above

Digit 4

0	1	2	3	4	5	6	7	
	o		o		o		o	Data from historical buffer 10 in report
		o	o			o	o	Data from historical buffer 11 in report
				o	o	o	o	Data from historical buffer 12 in report
o								None of the above

Digit 5

0	1	2	3	4	5	6	7	
	o		o		o		o	Data from historical buffer 13 in report
		o	o			o	o	Data from historical buffer 14 in report
				o	o	o	o	Data from historical buffer 15 in report
o								None of the above

Digit 6

0	1	
	o	Data from historical buffer 16 in report
o		None of the above

Configuration Code Addresses 050-056

Configuration Code Addresses 050-056 control the alarm status report, which lists all channels in alarm.

A false to true logic transition logic transition at a logic address generates the alarm status report. For example, you can configure the alarm status report so it is generated when a system timer resets or whenever a channel is in alarm.

After the alarm status report is generated, it can be output immediately or held in a text output buffer. Digi 4 Plus can also automatically dial user-programmed telephone numbers and transit alarm status reports. If you use a Kaye printer, a blank line follows each alarm status report.

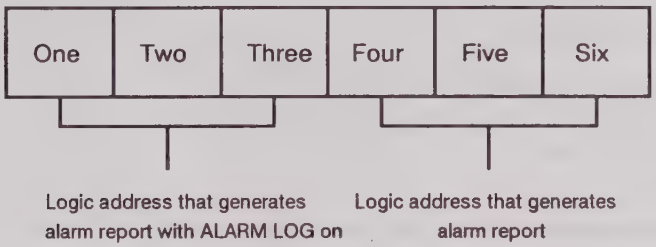
An alarm status report can contain:

- Up to 9 lines of header information
- Data from up to 128 channels
- Channel addresses and labels
- Status input and relay information

The following pages describe configuration codes that control alarm status reports. They are similar to the configuration codes that control data reports. See Section 9 for more information on alarm status reports.

Configuration Code Address 050

Purpose: Specify the logic addresses that generate the alarm status report.



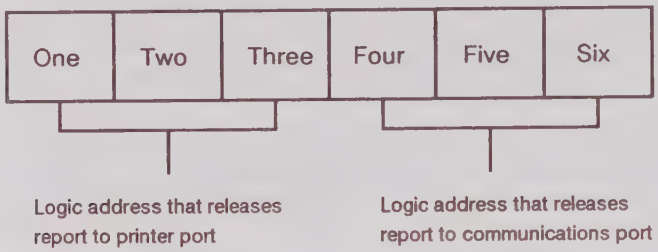
Digits 1-3 specify a logic address. When the logic bit at this address makes a FALSE/TRUE transition, the system generates the alarm status report if the ALARM LOG is active. To enable the ALARM LOG, press the ALARM LOG key rapidly twice.

Digits 4-6 specify a logic address. When the logic bit at this address makes a FALSE/TRUE transition, the system unconditionally generates the alarm status report.

The default value for Configuration Code Address 050 is 000000. The logic bit at Logic Address 000 is always TRUE. Since an alarm status report is generated when a logic bit makes a FALSE/TRUE transition, Logic Address 000 cannot generate an alarm status report. You must assign a non-zero Logic Address (other than 099).

Configuration Code Address 051

Purpose: Specify the logic addresses that release the alarm status reports stored in the text output buffer.



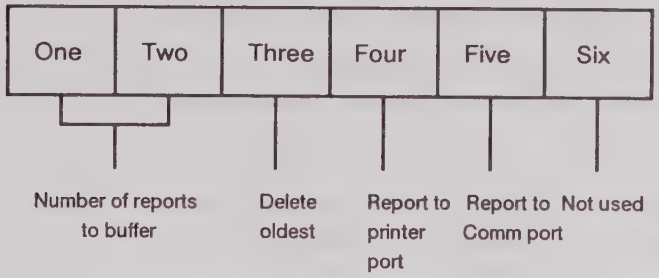
Digits 1-3 specify a logic address. When the logic bit at this address is TRUE, the system outputs all alarm status reports in the text output buffer that are destined for the printer port, even if the logic bit turns FALSE during transmission.

Digits 4-6 specify a logic address. When the logic bit at this address is TRUE, the system outputs all alarm status reports in the text output buffer that are destined for the communications port, even if the logic bit turns FALSE during transmission.

000000 is the default value for Configuration Code Address 051. The logic bit at Logic Address 000 is always TRUE and outputs alarm status reports as soon as they are generated.

Configuration Code Address 052

Purpose: Specifies the maximum number of alarm status reports stored in the text output buffer; whether the oldest is deleted when the buffer contains the maximum number; and the output port.



Digits 1-2 specify the maximum number of alarm status reports stored in the text output buffer.

When you specify Digits 1 and 2 as 00, the buffer can hold one "extra" alarm ststus report. If there is not enough memory to store text output, a buffer overflow occurs. A buffer overflow forces output of the data that caused the overflow and data may be lost. For more information on the text output buffer, see Section 9.

Digit 3 specifies whether the system deletes the oldest report when the buffer contains the maximum number.

Digit 4 instructs the system to send an alarm status report to the printer port. (On a Digistrip 4 Plus, the printer port is dedicated to the built-in printer. On a Digi-Link 4 Plus, it is connected an external printer.)

When Digit 4 = 1, the report is sent to the printer port.

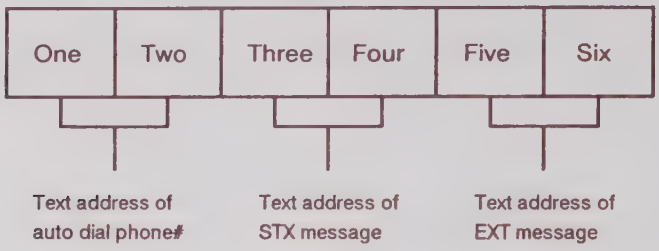
Digit 5 instructs the system to the report to the communications port for output to a local or remote printer/terminal or computer. A modem is required for remote transmission.

When Digit 5 = 1, the report is sent to the communications port.

Digit 6 is reserved. Assign a 0.

Configuration Code Address 053

Purpose: Specifies the text addresses that contain Auto-Dial telephone numbers, start-of-text and end-of-text messages.



Digits 1-2 specify the text address that contains the telephone number for automatic transmission of the alarm status report. See Section 11 for more information on Auto-Dial.

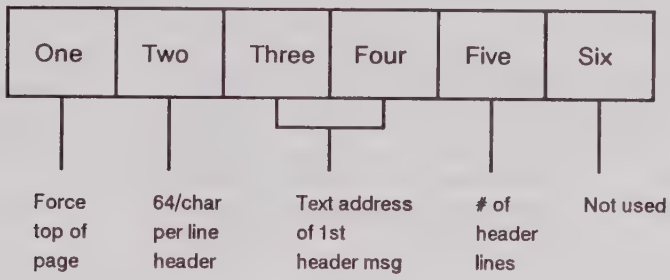
Digits 3-4 specify the text address that contains the start-of-text message. The system automatically outputs this message as part of the first line of the report.

Digits 5-6 specify the text address that contains the end-of-text message. The system automatically outputs this message as the final line of the report.

(The communications port CXT protocol does not support start-of-text and end-of-text messages. See Section 11 for more information on CXT protocol.)

Configuration Code Address 054

Purpose: Specifies whether alarm status reports appear on the same page with other report types; and the format and contents of the header.



Digit 1 specifies whether alarm status reports are on a separate page or with other reports.

When Digit 1 = 0 (default), the alarm status report can appear on the same page as a data report. When Digit 1 = 1, it is printed on a new page if the previous report was not alarm status report.

Digit 2 specifies a 64-character or 128-character header. Digit 2 = 0 formats 128 characters per header line (default); Digit 2 = 1 formats 64 characters per header line.

Digits 3-4 specify the text address (01-99) of the first of a group of consecutively addressed header messages.

Digit 5 specifies the number of lines (1-9) in the header.

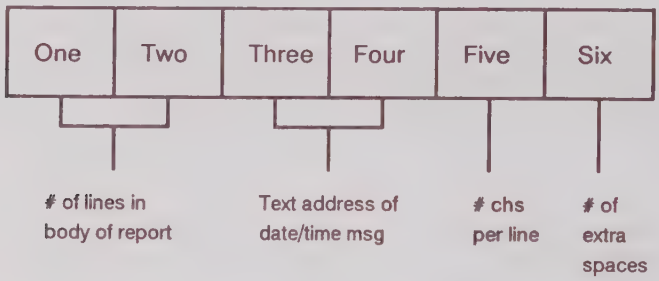
The text address specified in Digits 3 and 4 points to the first header message. The number of characters per line determines the number of consecutively addressed messages on each line.

128-character header. Each header line contains four 32-character messages.
64-character header. Each header line contains two 32-character messages.

Digit 6 is reserved. Assign a 0.

Configuration Codes Addresses 055

Purpose: Formats the body of the alarm status report.



Digit 1 specify the number of lines in the body of the alarm status report. The system compares the number of lines in the report with the number of lines per page specified in Configuration Code Address 004. If there are not enough lines on a page for the entire report, it begins the report at the top of the next page.

The first line contains the date/time the report was generated. The alarm status report can also contain additional lines, depending upon:

- The number of channels in alarm
- Placement of channel addresses and labels. (If channel addresses and/or labels are placed above the channel data, the system inserts a blank line after each line of data.)
- Whether it includes relay and status input information.

You can format reports to include blank lines after the data to provide more white space between reports. Simply add the number of blank lines to the total number of lines. For example, if Report 1 has 30 lines and you want 5 blank lines to follow it, assign 35 to Digits 1 and 2 of Configuration Code Address 015. (With a Kaye printer, a blank line follows each report.)

Digits 3-4 specify the text address (01-99) of the message on the first line of the data report (after date/time). 00 = no message.

Digit 5 specifies the number of channels per line (default = 0).

A value of 0 specifies the 16 channel per line format when channel addresses are on the line above the output data. A value of 0 specifies the 8 channel per line format when channel addresses are on the same line as the output data. Values of 1-9 specify 1-9 channels per line.

Digit 6 specifies extra spaces between channels. The number depends upon the format.

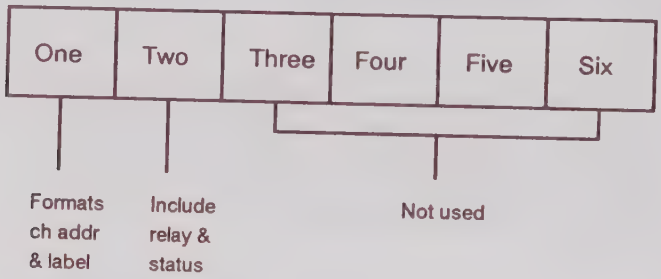
The Kaye printer can output up to 137 characters per line. Each channel is allocated a fixed number of characters.

Channel address	=	4 characters (3 digits and a space)
Label (optional)	=	9 characters (8 alphanumeric characters and a space)
Channel data	=	6 characters (5 digits with decimal point or minus sign; or 4 digits with decimal point and minus sign.)
Units	=	1 alphanumeric character
Alarm signal	=	1 character (* signals an alarm)

Example: With an 8-channel per line format, channel addresses and labels on the line above channel output data, each channel address requires 8 characters. The maximum number of characters per line on a Digi 4 printer is 137. 137 - (8 X 8) = 73. There are 73 extra spaces per line, so you can assign up to 9 extra spaces between channels.

Configuration Code Addresses 056

Purpose: Format channel addresses and labels and include the logic states of the relays and status inputs.



Digit 1 specifies whether the alarm status report contains labels. (Channel addresses are automatically included.) There are two formats for placing channel addresses and labels: on the same line as the data (default) or on the line above it.

If you select a 7, 8, 9 or 16 channel per line format, channel addresses and labels do not fit on the same line as the data. Place them on the line above.

0 1	2	3		
		o		o
			o	o
	o			

Channel addresses and labels on line above data
Inlude labels in report
None of the above

Digit 2 instructs the system to include the logic states of the 48 relays and 32 status inputs. Relay and status information requires 2 lines and follows channel data. To include the logic states, change the value of the digit to 1.

Digits 3-6 are reserved. Assign 0's.

Configuration Code Addresses 061-063

Configuration Code Addresses 061-063 control the buffering of messages. Messages are user-defined and can be issued when:

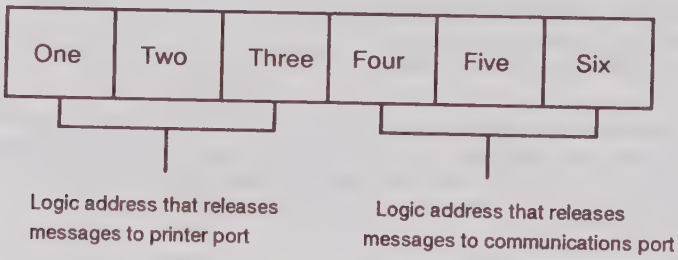
- Channel output data exceeds a user-defined limit
- Channel output data is over-range or open
- Relays are set by the sequencer function

After a message is generated, it can be output immediately or held in a text output buffer (in the same way as reports). Digi 4 Plus can also automatically dial user-programmed telephone numbers and transmit messages. With a Kaye printer, a blank line follows each message.

See Section 8 for more information on messages.

Configuration Code Address 061

Purpose: Specifies the logic addresses that release messages stored in the text output buffer.



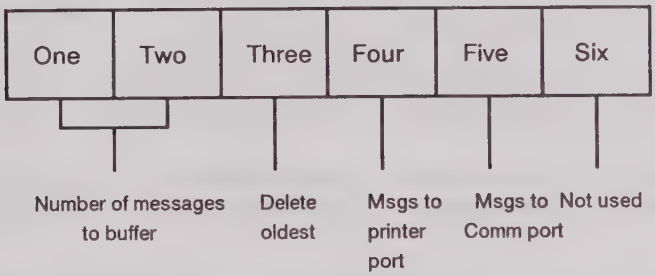
Digits 1-3 specify a logic address. When the logic bit at this address is TRUE, the system transmits all messages in the text output buffer that are destined for the printer port, even if the logic bit turns FALSE during transmission.

Digits 4-6 specify a logic address. When the logic bit at this address is TRUE, the system transmits all messages in the text output buffer that are destined for the communications port, even if the logic bit turns FALSE during transmission.

The default value for Configuration Code Address 061 is 000000. Because the logic bit at Logic Address 000 is always TRUE, messages are output as soon as they are generated.

Configuration Code Address 062

Purpose: Specifies the maximum number of messages held in the text output buffer; whether the oldest is deleted when the buffer contains the maximum number; and the output port.



Digits 1-2 specify the maximum number of messages stored in the text output buffer (default = 99). This assures output even if multiple messages are printed during the same math scan.

Digit 3 specifies whether the system deletes the oldest message when the buffer contains the maximum number.

Digit 4 configures the system to send the messages to the printer port. On a Digistrip 4 Plus, the printer port is dedicated to the built-in printer. On a Digi-Link 4 Plus, it connects to an external printer. When Digit 4 = 1 (default), messages are sent to the printer port. When Digit 4 = 0, they are not.

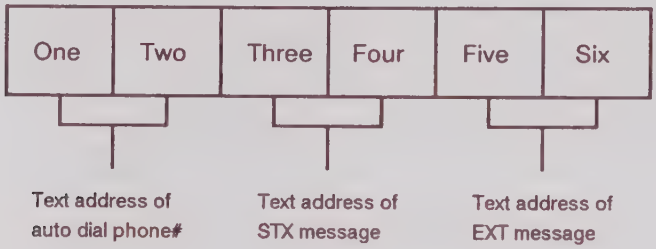
Digit 5 instructs the system to send messages to the communications port for output to a local or remote printer/terminal or computer. A modem is required for remote transmission.

When Digit 5 = 1, messages are sent to the communications port. When Digit 5 = 0 (default), they are not.

Digit 6 is not used. Assign a zero.

Configuration Code Address 063

Purpose: Specifies the text addresses that contain Auto-Dial telephone numbers, start-of-text and end-of-text messages.



Digits 1-2 specify the text address that contains the telephone number for automatic transmission of a messages. See Section 11 for more information on Auto-Dial.

Digits 3-4 specify the text address that contains the start-of-text message. The system automatically outputs the STX message before each message.

Digits 5-6 specify the text address that contains the end-of-text message. The system automatically outputs the EXT message after each message.

(The communications port CXT protocol does not support start-of-text and end-of-text messages. See Section 11 for more information on CXT protocol.)

Configuration Code Addresses 071-073 control buffering of accumulation totals. (An accumulation total is output from a channel assigned a Function Code 056-058. The function determines the destination of the accumulation total.)

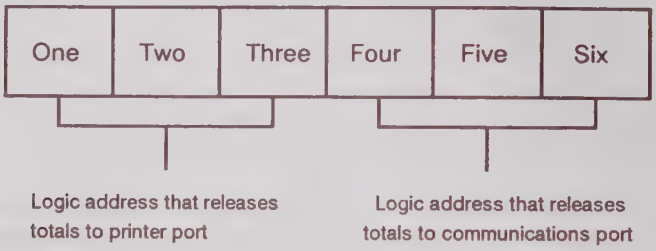
Function Code	Description
056	Accumulation total to printer port
057	Accumulation total to communications port
058	Accumulation total to printer port and communications port

After an accumulation total is generated, it can be output immediately, or stored in a text output buffer. You can specify the maximum number held, but not the delete oldest feature.

Digi 4 Plus can also automatically dial user-programmed telephone numbers and transit accumulation totals. You can specify start-of-text and end-of-text messages for accumulation totals. With a Kaye printer, a blank line follows each accumulation total.

Configuration Code Address 071

Purpose: Specifies the logic addresses that release accumulation totals stored in the text output buffer.



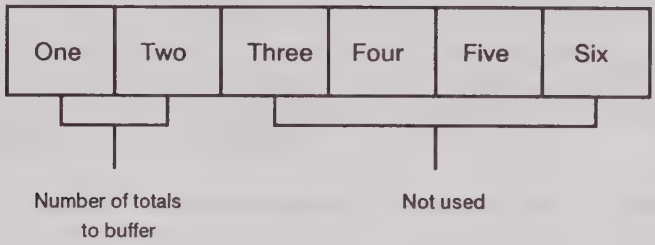
Digits 1-3 specify a logic address. When the logic bit at this address is TRUE, the system transmits all accumulation totals in the text output buffer that are destined for the printer port, even if the logic bit turns FALSE during transmission.

Digits 4-6 specify a logic address. When the logic bit at this address is TRUE, the system transmits all accumulation totals in the text output buffer that are destined for the communications port, even if the logic bit turns FALSE during transmission.

The default value for Configuration Code Address 071 is 000000. Because the logic bit at Logic Address 000 is always TRUE, accumulation totals are output as soon as they are generated.

Configuration Code Address 072

Purpose: Specifies the maximum number of accumulation totals held in the text output buffer.

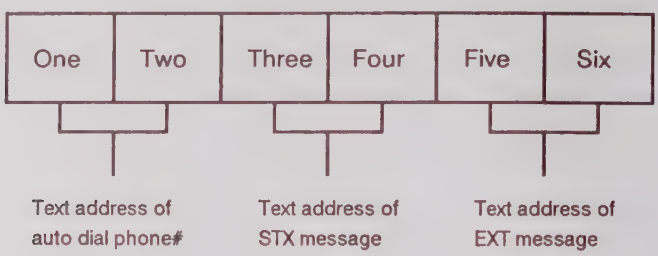


Digits 1-2 specify the maximum number of messages stored in the text output buffer (default = 99). This assures output even if multiple messages are printed during the same math scan. For more information on the text output buffer, see Section 9.

Digits 3-6 are not used. Assign 0's.

Configuration Code Address 073

Purpose: Specifies the text addresses that contain Auto-Dial telephone numbers, start-of-text and end-of-text messages.



Digits 1-2 specify the text address that contains the telephone number for automatic transmission of accumulation totals. See Section 11 for more information on Auto-Dial.

Digits 3-4 specify the text address that contains the start-of-text message. The system automatically outputs the STX message before the accumulation total.

Digits 5-6 specify the text address that contains the end-of-text message. The system automatically outputs the EXT message after the accumulation.

(The communications port CXT protocol does not support start-of-text and end-of-text messages. See Section 11 for more information on CXT protocol.)

Digits 1-6 specify a six-digit password required to enter the Program mode. The default is 000000. You define any value between 000000 and 999999. The system does not display the password assigned to Configuration Code Address 901 unless it is in the Program mode.

If you assign a password to Configuration Code Address 901, you must also specify password protection at Configuration Code Address 009. If you specify password protection but fail to assign a password to Configuration Code Address 901, the system assumes the password is 000000.

The value stored at Configuration Code Address 901 is not displayed unless the system is in Program mode.

Configuration Code Address 902

Configuration Code Address 902 stores the computer access (CXT) password. The default is 000000. The password is not displayed unless the system is in the Program mode.

The unit identifier (UID), set by Slides 4-8 of DIP Switch S7, determines the format of this password.

- If the **Digi's UID is 00**, the computer access password is 00 followed by 4 digits, any value between 0000 and 9999. For example, to define a CXT access password of 001234, set the Digi UID for 00 and assign 001234 to Configuration Code Addresses 902.

- If the **Digi's UID is 01 to 31**, the computer access password is the UID followed by 4 zeros. For example, if the UID is 15, enter 150000 at Configuration Code Address 902.

With KVIEW, Mini-KVIEW, KDIAL and The Programmer software, Configuration Code Address 902 must be 000000.

10.3 RELAY LATCHING CONFIGURATION CODES 101-148

Configuration Codes 101-148 specify which (if any) relays are latched at power-up. A relay latching configuration code contains one digit: 0 or 1. The configuration code addresses correspond to Relay Addresses 01-48. (The relays control the logic bits at Logic Addresses 001-048.)

Relay activation depends upon the assigned limit and op-codes or Function Code 150 (sequencer function). When a relay is activated, the logic bit at the corresponding logic address is TRUE; at all other times, it is FALSE.

The first math scan after a power-outage, a latched relay is held in the state it was in prior to the outage. A non-latched relay is always set FALSE after a power outage.

When you initialize the system, all relay latching configuration codes have a value of 0; none are designated latched relays. To configure relay as a latched relay, assign a 1 to the corresponding configuration code address.

To assign values to a configuration code address:

- Press the PROGRAM key. If necessary, key in your password.
- Press the CONFIG CODE key. The upper display contains the address of the last configuration code accessed. The lower and alphanumeric displays are blank.
- Key in the configuration code address, or press the INCREMENT or DECREMENT key to access the address. Press the ENTER Key.
- Assign a 1 to specify a latched relay. (Assign a 0 if you do not want the relay latched.) Press the ENTER key.

10.4 SEQUENCER CONFIGURATION CODES 201-299

Configuration Code Addresses 201-299 are used with Function Code 150 (sequencer function). See the Digi 4 Sequencer Function (M4131) for more information.

SECTION 11 - COMMUNICATIONS PORT

11.1 GENERAL INFORMATION 11-1

11.2 TRM PROTOCOL 11-3
- 11.2.1 Defining TRM Operation 11-3
- 11.2.2 Auto-Dial 11-4
- 11.2.3 TRM Transmissions 11-7

11.3 CXT PROTOCOL. 11-8
- 11.3.1 Defining CXT Protocol 11-8
- 11.3.2 CXT Communications 11-11
- 11.3.3 Error Handling 11-20
- 11.3.4 CXT Commands and Responses Tables 11-22

11.1 GENERAL INFORMATION

The communications port (COMM port) is a standard Digi 4 Plus feature that provides two mutually exclusive protocols, terminal protocol (TRM) and computer extended protocol (CXT), for communication with external devices.

Terminal Protocol

Use TRM protocol to communicate with a terminal, printer, CRT, an application that includes Auto-Dial or with Kaye's switched network software package (KDIAL).

Computer Extended Protocol

Use CXT protocol to communicate with a computer or with Kaye's multi-drop network software packages (KVIEW and KDAWS).

Both protocols support full-duplex, asynchronous, serial data communication with external devices. Characters have one start bit, seven data bits, one parity bit (even) and one stop bit. External devices are connected to the current loop communications port or the RS-232 communications port on the Interface I/O panel (Figure 11-1).

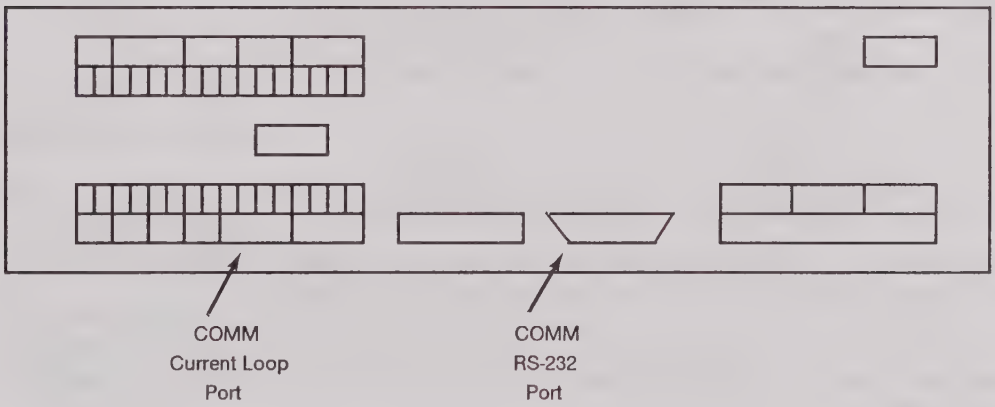


Figure 11-1. Interface I/O Panel COMM Ports

Current Loop Connections

Use the current loop communications port to direct wire external devices that use only transmit (TX) and receive (RX) signals. (Figure 11-2)

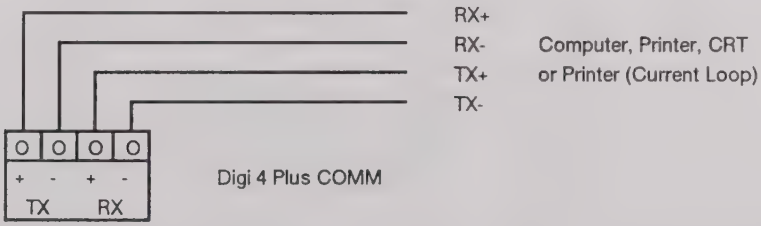


Figure 11-2. Current Loop Connections

If the external device is passive, set the COMM TX and COMM RX toggle switches on the Interface I/O panel for active operation. If the external device is active, set them for passive operation.

RS-232-C Connections

The RS-232-C Communications port is wired in DTE configuration. Use a standard RS-232-C cable with transmit, receive and ground pins (2, 3 and 7) to connect an external device to this port.

If the external device is wired in DCE configuration, use a standard RS-232-C cable with the following pin configurations:

Digi 4 COMM RS-232 Port (DTE)	External Device RS-232-C Port (DCE)
Pin 2 (TX)	Pin 2 (RX)
Pin 3 (RX)	Pin 3 (TX)
Pin 7 (GND)	Pin 7 (GND)

If the external device is wired in DTE configuration, use a standard RS-232-C cable with the following pin configurations:

Digi 4 COMM RS-232 Port (DTE)	External Device RS-232-C Port (DTE)
Pin 2 (TX)	Pin 3 (RX)
Pin 3 (RX)	Pin 2 (TX)
Pin 7 (GND)	Pin 7 (GND)

If the external device requires data terminal ready (DTR) and request to send (RTS) hand-shakes, specify a 1 for Digit 6 of Configuration Code Address 005.

If the link includes RS-232-C modems, additional circuits may be required. Table 11-1 shows the modem support circuits. See the documentation supplied with your modems for more information.

Table 11-1. COMM Port RS-232-C Modem Support Circuits

Pin No.	Circuit Name	Circuit Description	Circuit Abbrev.
1	AA	Protective Ground	--
2	BA	Transmitted Data	TX
3	BB	Received Data	RX
4	CA	Request to Send	RTS
5	CB	Clear to Send	CTS
6	CC	Data Set Ready	DSR
7	AB	Signal Ground (Com. Ret.)	GND
8	CF	Received Line Signal Detector	DCD
20	CD	Data Terminal Ready	DTR
22	CE	Ring Indicator	RI

To enable switched network access, set Digit 5 of Configuration Code Address 005 to 1.

11.2 TRM PROTOCOL

TRM protocol provides full duplex, asynchronous serial data communications in current loop or RS-232 formats. TRM governs output to an external printer, terminal or CRT. You also set the Digi 4 Plus in TRM if you enable Auto-Dial or run KDIAL.

TRM protocol can be used to:

- o Transmit reports
- o Transmit limit and sequencer messages
- o Transmit accumulation totals
- o Communicate via RS-232-C modems
- o Support Auto-Dial for reports, messages and accumulation totals
- o Set Logic Bits 085-088 true for one math scan
- o Stop, restart and cancel text outputs in progress
- o Override the Auto-Dial lockout

11.2.1 Defining TRM Operation

DIP Switch S2 on the Data acquisition board (4 Plus DA) specifies the communications protocol and enables modem support and special features.

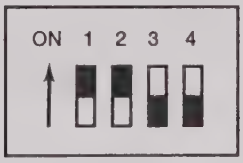
Slide 1 specifies the communications protocol. Set it on (TRM).

Slide 2 specifies modem support. If the communications link includes modems, set it on.

Slide 3 is not used. Set it off.

Slide 4 sets Logic Bits 085-088 true for one math scan, cancels data transmissions in progress and override the Auto-Dial lockout. These features are enabled if Slide 4 is off. To disable them, set it on.

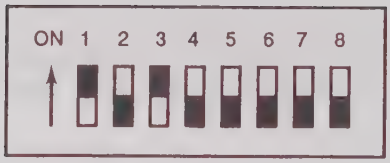
The figure below shows DIP Switch S2 set for TRM protocol, modem support, special features enabled.



Slides 1, 2 and 3 of DIP Switch S7 (Interface I/O panel) specify the communications port baud rate. Table 11-2 lists the settings. The figure shows a setting of 4800 baud.

Table 11-2. COMM Port Baud Rate

Baud Rate	Slide 1	Slide 2	Slide 3
110	OFF	OFF	OFF
300	OFF	OFF	ON
600	OFF	ON	OFF
1200	OFF	ON	ON
2400	ON	OFF	OFF
4800	ON	OFF	ON
9600	ON	ON	OFF



The system reads DIP switch settings at power up. If you change a DIP Switch setting, power off and then on again.

Switched Network

If you connect a Digi 4 Plus to the external device via RS-232-C modems and switched telephone lines, specify a 1 for Digit 5 of Configuration Code Address 005.

Switched network support is required for Auto-Dial and KDIAL. If Slides 1 and 2 of DIP Switch S2 (Data 4 board) are on when the system is initialized, the Digi 4 Plus automatically sets Digit 5 = 1. Slides 1 and 2 specify TRM protocol and modem support.

If Slides 1 and 2 were not on when the system was initialized, you can enter a 1 in Digit 5. However, the Digi 4 Plus reads the changes to this digit only at power-up.

11.2.2 Auto-Dial

Digi 4 Plus can automatically call a programmed telephone number and transmit reports or messages. When transmission is complete, it hangs up. To use this feature:

- o Connect Auto-Dial RS-232 modems to Digi 4 Plus' RS-232 communications port and a switched network telephone line
- o Set Digi 4 Plus in TRM (DIP Switch 2, Slide 1 on)
- o Select modem support (DIP Switch 2, Slide 2 on)

Auto-Dial is automatically enabled on power-up if you connect a Hayes 1200 or 2400 Smartmodem to Digi's RS-232 communications port. After system initialization, turn the modem on before Digi 4 Plus. Digi 4 Plus software enables Auto-Answer. The table below shows switch settings for the Hayes 1200 modem. The Hayes 2400 modem does not have switches; Digi 4 Plus automatically configures it.

Slide	1	2	3	4	5	6	7	8	9	10
Hayes 1200	Up	Dn	Dn	Dn	Dn	Up	Up	Dn	Up	Up

To complete a telephone connection between Digi 4 Plus and a computer, Digi must be in TRM mode. CXT Command 91 switches Digi from TRM to CXT mode and lets the computer control the transmission. See Table 11-12 for more information.

Digi 4 Plus continuously monitors the Data Set Ready (DSR) line. If the DSR line turns off; i.e., modem power is off or the line is disconnected, Digi 4 Plus beeps 10 times (once every two seconds) and issues the following message when power returns or the line is reconnected:

MODEM ON-LINE AT: 04/15/86 14:57:14 (04/15/86 14:57:14) S5225 V1.00

Time of system reset

Software level

The system resets when the modem comes on-line: the watch dog relay trips momentarily and Logic Bit 084 turns on for one math scan.

With Auto-Dial enabled, Digi 4 Plus can call the programmed telephone number and transmit the report or message. Simply enter an Auto-Dial telephone number or alternate number(s) at one of Digi's 99 text addresses. Each text address contains 32 characters. You can program the same numbers for more than one output type.

Precede the number with the letter P (pulse) or T for (touch tone). Separate multiple telephone numbers with a slash (/) and program a space immediately after the last telephone number. You can also include the letter W to instruct the modem to wait for a dial tone. Table 11-3 contains sample Auto-Dial telephone numbers.

Table 11-3. Sample Auto-Dial Phone Numbers

Type of Call	Telephone Number(s) Called	Information Programmed at Text Address XXX
Local call (pulse dial)	444-1234	P4441234_
Local call w/alternate number	444-1234 942-1212	P4441234/P9421212_
Local call from PBX extension (9 is the outside line access code)	9-444-1234	P9W4441234_
Long distance call within same area (tone dial)	1-225-4141	T12254141_
Long distance call to another area	1-602-268-2025	P16022682025_
Long distance call to another area w/alternate number	1-602-268-2025 1-602-268-1102	P16022682025/P16022681102_
Long distance call to another area w/alternate number from a PBX extension	9-1-505-335-1122 9-1-505-485-1175	P9W15053351122/P9W15054851175_

Precede each telephone number with P (pulse dial) or T (tone dial).

Program a space (_) at the end of the telephone number series.

When calls originate from a PBX exchange, precede each telephone number with a command (the letter W) that waits for the dial tone.

The call waiting tone provided in some PBX systems, and available as an option in some public telephone systems, interferes with Auto-Dial operation. When setting up a system with Auto-Dial, connect the Auto-Dial modem to a telephone line that does not have a call waiting tone.

Assign the text address storing the telephone number to the configuration code that controls the output type.

Configuration Code Addresses	Stores Telephone Number for
013	Data Report 1
023	Data Report 2
033	Data Report 3
043	Data Report 4
053	Alarm Status Report
063	Messages
073	Accumulation Totals

When you program a single Auto-Dial phone number, Digi 4 Plus calls that number when it has text to transmit. If it cannot reach the number within 45 seconds, it hangs up and tries again in 30 seconds. It repeats the procedure until the call is completed. Digi 4 Plus interprets invalid characters in the telephone number as busy signals.

When you program multiple Auto-Dial phone numbers, Digi 4 Plus calls the first number when it has text to transmit. If it cannot reach that number within 45 seconds, it hangs up, waits 30 seconds and calls the second number. If it cannot reach the programmed numbers, it cycles through the programmed numbers until it completes the call. Digi 4 Plus interprets invalid characters in the telephone number as busy signals.

If more than one text output type is pending at the same time, Auto-Dial transmits text output in the following order:

- o Messages (limit and sequencer)
- o Accumulation totals
- o Alarm status reports
- o Data Report 1
- o Data Report 2
- o Data Report 3
- o Data Report 4

If Auto-Dial cannot reach the telephone number for the highest priority text output, it tries to transmit text output with the next highest priority (and a different Auto-Dial telephone number). After it tries all pending text outputs, Auto-Dial returns to the highest priority text output and tries again.

When Auto-Dial completes a transmission, it checks to see if there are other text outputs waiting transmission to the same telephone number. If there are, it transmits them in order of priority before Digi 4 Plus hangs up.

If Digi 4 Plus detects a dial-in, it performs an Auto-Answer and transmits text outputs configured for the Communications Port but not flagged for Auto-Dial transmission. The Auto-Dial override command can request transmission of text outputs flagged for Auto-Dial transmission.

Overriding Auto-Dial Lockout

Digi 4 Plus does not transmit text outputs flagged for Auto-Dial if it cannot reach any programmed Auto-Dial telephone numbers. The TRM special features option provides an Auto-Dial override command that can initiate transmission of text outputs flagged for Auto-Dial transmission. The format of the Auto-Dial cverride command is:

(SOC)(INSTR)(EOC)

Where:

(SOC) = Start of command character (#)
(INSTR) = Instruction (single digit number in the range 1-7)
(EOC) = End of command character (carriage return)

The instruction field specifies the text output that is transmitted. Table 11-4 shows how the value of the field is determined.

Table 11-4. Instruction Field Values

Text Output	Value
Messages (Limit & Sequencer)	1
Accumulation Totals	2
Alarm Status Reports	3
Data Report 1	4
Data Report 2	5
Data Report 3	6
Data Report 4	7

11.2.3 TRM Transmissions

TRM protocol supports ASCII asynchronous serial data transmission of the following Digi 4 Plus text outputs:

- o Data Report 1, 2, 3 and 4
- o Alarm status reports
- o Messages (limit & sequencer)
- o Accumulation totals

Configuration Code Addresses 010-062 control all text outputs. Use these configuration codes to transmit data via the communications port and to format the reports. See Section 10 for more information.

Interrupting and Resuming Transmissions

Use the XOFF control character to interrupt transmission and the XON control character to resume transmission.

Cancelling Transmissions

Use the CANCEL control character to end a text transmission in progress.

Setting Logic Bits

You can set Logic Bits 085-088 true for one math scan. These logic bits can generate reports and trigger printouts. The command to set these logic bits is:

(SOC)(INSTRUCTION)(EOC)

Where:
(SOC) = Start of command character (#)
(INSTR) = Instruction (2-digit number in range 00-15)
(EOC) = End of command character (carriage return)

The instruction field specifies the logic bits that are set true. The value of this field is the sum of the values of the bits selected. For example, to set Logic Bits 085 and 086, the value is 03.

Logic Bit	Value
085	01
086	02
087	04
088	08

11.3 CXT PROTOCOL

CXT protocol supports communications between a computer and one or more Digi 4 Plus'. You create an interface between the computer and Digi through a series of commands and responses. The computer initiates all transactions; Digi 4 Plus responds after it receives a valid command.

If the computer sends a CXT command to the place the Digi 4 Plus in the Program mode and it is already in the Program mode from the operator panel, the Digi 4 Plus yields the Program mode to the CXT protocol. When the computer sends a deaccess command, the Digi 4 Plus returns to the Program mode.

CXT protocol automatically checks the system for communications errors. If one occurs, Digi 4 Plus either sends an error message, waits 5 seconds and deaccesses, or deaccesses immediately (depending on the error). This allows the computer to initiate and complete recovery quickly.

Kaye's CXT protocol guarantees secure transmissions. Reports and messages are not deleted from Digi's memory (text output buffer) until the computer receives the entire transmission.

CXT protocol can be used to:

- o Transmit reports and messages
- o Transmit accumulation totals and program listings
- o Communicate via RS-232-C modems
- o Stop and restart of text outputs in progress
- o Perform remote programming and data return

11.3.1 Defining CXT Protocol

DIP Switch S2 on the Data acquisition board (4 Plus DA) specifies the communications protocol and enables modem support. DIP Switch S7 on the Interface I/O panel) specifies the communications port baud rate and Digi's unit identifier (UID).

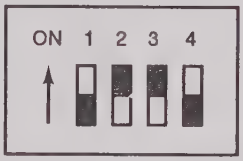
DIP Switch S2

Slide 1 specifies the communications protocol. Set it off.
Slide 2 specifies modem support. If the communications link includes modems, set it on.

Slide 3 specifies line feed at the end of each Digi response message. If your computer application requires a line feed, set it on.

Slide 4 is not used. Set it off.

The figure below shows DIP Switch S2 set for CXT protocol, modem support and line feed.

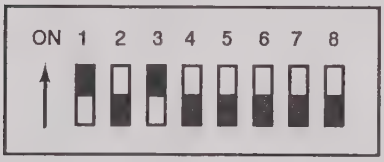


DIP Switch S7

Slides 1-3 specify the baud rate. Table 11-5 lists the baud rates. The figure shows DIP Switch S7 set for 4800 baud.

Table 11-5. COMM Port Baud Rate

Baud Rate	Slide 1	Slide 2	Slide 3
110	OFF	OFF	OFF
300	OFF	OFF	ON
600	OFF	ON	OFF
1200	OFF	ON	ON
2400	ON	OFF	OFF
4800	ON	OFF	ON
9600	ON	ON	OFF



The system reads DIP switch settings at power up. If you change a DIP Switch setting, power off and then on.

Slides 4-8 specify the UID. The UID is a 2-digit number (00-31) that identifies individual Digi's. In a multi-drop network and with Kaye software packages, each Digi must have a unique UID. The UID also determines the format of the computer (CXT) access password.

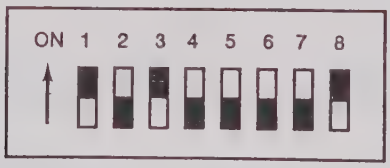
- o If Digi's UID is 01 to 31, the computer access password is the UID followed by 4 zeros. For example, if a UID is 21, its CXT access password is 210000.
- o If Digi's UID is 00, the computer access password is 00 followed by 4 digits, 0000 to 9999. For example, if a UID is 00, its CXT access password could be 001234. Configuration Code Address 902 stores the CXT access password.

The data field of each access command (Command 000) must include the CXT access code. The CXT Access Code identifies the Digi 4 Plus being accessed.

Table 11-6 lists the UID's. The figure shows DIP Switch S7 set for a UID of 1.

Table 11-6. Unit Identifier (UID)

Unit Identifier	Slide Settings Slide 4	Slide 5	Slide 6	Slide 7	Slide 8
00	OFF	OFF	OFF	OFF	OFF
01	OFF	OFF	OFF	OFF	ON
02	OFF	OFF	OFF	ON	OFF
03	OFF	OFF	OFF	ON	ON
04	OFF	OFF	ON	OFF	OFF
05	OFF	OFF	ON	OFF	ON
06	OFF	OFF	ON	ON	OFF
07	OFF	OFF	ON	ON	ON
08	OFF	ON	OFF	OFF	OFF
09	OFF	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON	OFF
11	OFF	ON	OFF	ON	ON
12	OFF	ON	ON	OFF	OFF
13	OFF	ON	ON	OFF	ON
14	OFF	ON	ON	ON	OFF
15	OFF	ON	ON	ON	ON
16	ON	OFF	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON
18	ON	OFF	OFF	ON	OFF
19	ON	OFF	OFF	ON	ON
20	ON	OFF	ON	OFF	OFF
21	ON	OFF	ON	OFF	ON
22	ON	OFF	ON	ON	OFF
23	ON	OFF	ON	ON	ON
24	ON	ON	OFF	OFF	OFF
25	ON	ON	OFF	OFF	ON
26	ON	ON	OFF	ON	OF
27	ON	ON	OFF	ON	ON
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF
31	ON	ON	ON	ON	ON



Computer Access

When Digi communicates with a computer, Digit 6 of Configuration Code Address 005 must have a value of 1 (default) to enable computer access. If you change the value, a communications error occurs.

Communications Link

If your system contains a single Digi 4 Plus, you can use the following configurations:

CXT Point-to-Point (direct-wired). Digi's transmit and receive signals are wired directly to the external device via the COMM RS-232 port or the COMM current loop port.

CXT Point-to-Point (modems). Digi is connected to the external device via point–to-point RS-232-C modems and a dedicated telephone line.

CXT Switched Network (modems). Digi is connected to the external device via RS-232-C modems and a switched telephone line.

If your system contains multiple Digi's, you can use the following configurations:

CXT Multi-Drop (direct-wired). Multiple Digi's are wired directly into the current loop COMM port. A Kaye Communications Expander is required.

CXT Multi-Drop (modems). Multiple Digi's are connected into the communications link via multi-drop RS-232-C modems and dedicated lines.

CXT Switched Network (modems). Multiple Digi's are connected into the communications link via RS-232-C modems and switched telephone lines. Only one Digi 4 Plus is on-line at a time.

11.3.2 CXT Communications

All CXT transactions are executed via specially formatted messages called commands and responses.

Commands are messages a computer sends to Digi 4 Plus.

Responses are messages Digi 4 Plus sends to a computer.

The computer initiates all transactions. Digi 4 Plus responds after it receives a valid command and only if the command requires a response. All commands except Command 90 (broadcast time) and Command 001 (de-access) require a response. Each CXT transaction is completed before another begins.

If the CXT software is delayed more than 100 milliseconds in responding to a command, Digi 4 Plus sends a dollar sign ($) character indicating a response is to be expected shortly.

Figure 11-3 on the following page shows the command message format. Figure 11-4 shows the response message format.

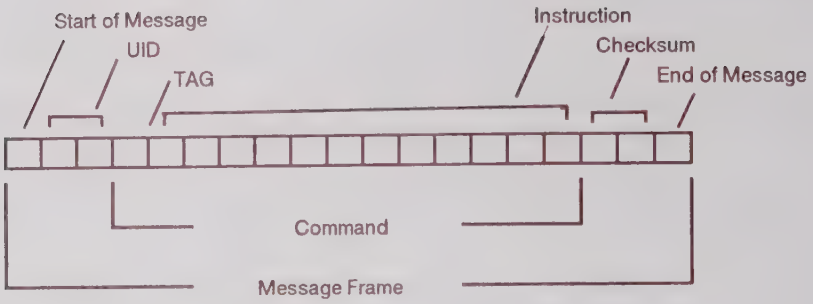


Figure 11-3. Command Message Format

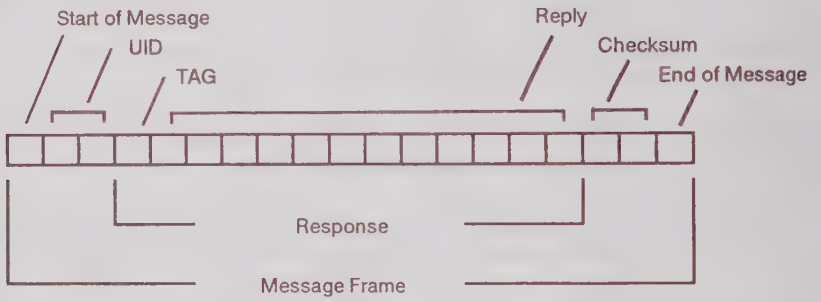


Figure 11-4. Response Message Format

In multi-drop systems, broadcast messages transmit information to multiple Digi 4's concurrently. Broadcast messages have a different format than command messages and invoke no response from a Digi 4 Plus.

When the computer sends an XOFF character, the text output transmission in progress is interrupted. When it sends an XON character, the transmission resumes where it was interrupted.

Command Messages

Each CXT command message has six data fields:

(SOM)(UID)(TAG)(INSTRUCTION)(CHECKSUM)(EOM)

SOM (start of message) is a single-character field that indicates the start of a command message. It must contain the @ character.

UID (unit identifier) is a 2-character field that identifies individual Digi's.

TAG is a single-character field that assures proper message sequencing. Command 000 (access command) sets initial tag value, which must be in the 0-9 range. The tag of each new command message must be the next number in sequence (with 0 the next number after 9). A repeated command message must be the same as the original command message including the tag.

INSTRUCTION is the field that provides the operating instruction to the Digi. The first three characters contain the command code. The remaining characters contain the data. Figure 11-5 shows the INSTRUCTION field format.

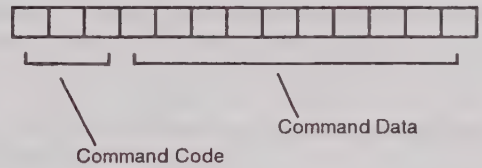


Figure 11-5. Instruction Field Format

CHECKSUM is a 2-character field used for communications error detection. If you use the checksum feature, the value in this field must equal the sum of the bit values of the previous characters in the message. If you do not use the Checksum feature, enter two asterisks (**).

EOM (end of message) is a single-character field that indicates the end of a command message. It must contain a carriage return (CR).

Command Classes and Command Codes

The first three characters of the INSTRUCTION field contain a command code that identifies the type of action Digi 4 Plus is to carry out. The first character indicates the command class (Table 11-7).

Table 11-7. Command Classes

Command Class	Command Code
Exception Commands	000-007
Broadcast Commands	90-91
Direction Action Commmands	100-128
Listing Commands	200-209
Inspection Commands	300-354
Programming Commands	400-454
Programming/Inspection Commands	500-554
Transparent Commands	900-999

Exception Commands access and de-access a Digi 4 Plus, set the system clock and change the disposition of printout transmissions. Commands 000-007 are valid exception commands.

Direct Action Commands set logic bits, enable and disable auto log, alarm log and PROGRAM mode, request and delete transmissions of pending text outputs, and set the parameter modification flag. Commands 100-128 are valid Direct Action Commands.

Listing Commands request transmission of program parameter listings. Commands 200-209 are valid listing commands.

Inspection Commands return the current value of a Digi 4 Plus parameter. Commands 300-354 are valid inspection commands.

Programming Commands program Digi 4 Plus parameters. Commands 400-454 are valid programming commands.

Programming/Inspection Commands program new Digi 4 Plus parameters and return the newly programmed values. Commands 500-554 are valid programming/inspection commands.

Transparent Commands are reserved for future applications; do not use them with current Digi software. If a properly formatted message is transmitted with a 9xx command code, Digi takes no action, but transmits an execution response of 300.

Non-implemented Commands are all commands other than those listed in Table 11-12 and other than those with a 9xx command code. If Digi 4 Plus receives a non-implemented command code, it transmits an execution response of 399. Non-implemented commands include all 6xx, 7xx and 8xx commands and all undefined commands with command codes 0xx, 1xx, 2xx, 3xx, 4xx and 5xx.

Command Data Formatting

The data values of all programming commands (Command Code 4xx) and programming/inspection commands (Command Code 5xx) follow the command code. All command data values must conform to the following rules:

- No lower case or control characters.
- Numeric entry characters are the digits (0-9), a minus sign (-) and a decimal point (.). Some numeric data values allow digits only.
- Numeric entries are right justified in their field.
- Numeric fields must be padded to their full length with zeros. Numeric fields that allow a sign and/or a decimal point must have their digit field padded with zeros and a leading blank included for each sign or decimal point allowed but not entered. The only exception is Command Code 421.
- Numeric fields that contain a decimal point must have a digit preceding the decimal point.
- Text entry characters include numerical entries, upper case letters, comma (,), left parenthesis (), right parenthesis ()), asterisk (*), slash (/) and plus sign (+).
- Text entries are left justified in their fields. Channel labels use only the first eight (8) characters.
- All text entries are 32 characters. The unused portion must be padded with blanks.
- The pound sign (#) can replace any text or numerical data value. It assigns the null value to the parameter. If you use the pound sign, it must be left justified and the rest of the field padded with blanks.

Broadcast Commands

CXT protocol also supports a broadcast time command (Broadcast Code 90). When it is transmitted, the system clock in each Digi is automatically synchronized. The system clocks are set when the seconds of the received time increment to zero. The format of the Set Time Broadcast Message is MMDDHHMMSS.

A broadcast command can be transmitted to all Digi's in a multi-drop system concurrently. The format differs from the other CXT commands and Digi does not issue a response message (Figure 11-6).

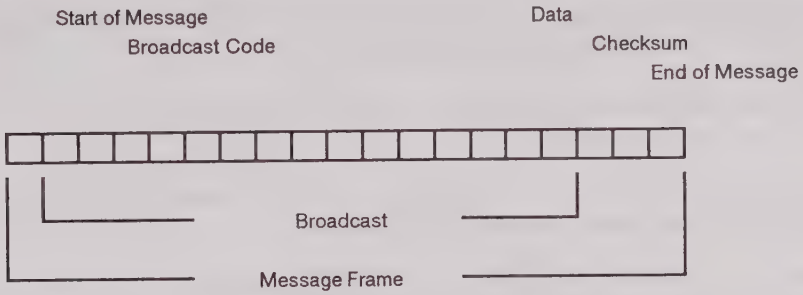


Figure 11-6. Broadcast Command Format

Broadcast Command to Switch Digi's from TRM to CXT Mode

For some applications you must set Digi 4 Plus in TRM mode and a computer switches it to CXT mode. For example, Digi 4 Plus must be in TRM mode to complete a telephone connection. When the connection is made, the computer switches Digi 4 Plus to CXT mode and takes control of the transmissions.

CXT Command 91 switches a Digi 4 Plus from TRM mode to CXT mode and asks the Digi 4 Plus to identify itself. Digi 4 Plus responds with its UID, a tag number for message sequencing, a 32 character user-defined message, a checksum and a carriage return. Then the computer sends an access command and the Digi 4 Plus responds.

Command 91 and the access command must follow within 10 seconds of the line connect. If the computer access password does not match, Digi 4 Plus hangs up. Digit 5 of Configuration Code Address 005, if enabled, causesa 25 second delay between successive access commands.

To end communication, the computer transmits a de-access command (001). When the connection is broken, Digi 4 Plus returns to TRM mode.

If Digi 4 Plus initiated the connection to transmit data but does not receive a Command 91 and the access command within 10 seconds, it transmits the data in TRM mode.

Response Messages

Each CXT response message has six data fields:

(SOM)(UID)(TAG)(REPLY)(CHECKSUM)(EOM)

CXT protocol starts a time-out after receiving a valid command from the computer. If the CXT software is delayed for more than 100 milli-seconds in responding to the command, Digi 4 Plus sends a dollar sign ($) character indicating a response is expected shortly.

SOM (Start of Message) is a single-character field that indicates the start of a response message. It must contain the @ character.

UID (Unit Identifier) is a 2-character field. It must echo the contents of the UID field in the command message.

TAG is a single-character field that assures proper message sequencing. It must echo the TAG field contents in the command message.

REPLY is a field that provides Digi's reply to the operating instruction in the command. The first character contains the response class code. The remaining characters contain the response data. Figure 11-7 shows the REPLY field format.

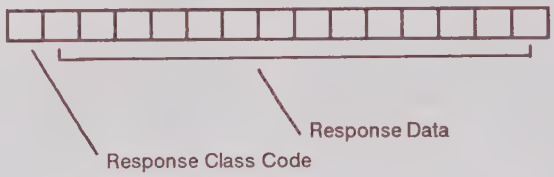


Figure 11-7. Reply Field Format

CHECKSUM is a 2-character field used for communications error detection. If you use the checksum feature, the value of this field must equal the sum of the bit values of the previous characters in the message. If you do not use the checksum feature (when two asterisks are transmitted in the CHECKSUM field of the command message), the CHECKSUM field of the response message also contains two asterisks.

EOM (End of Message) is a single-character field that indicates the end of a response message. It must contain a carriage return.

Response Class and Codes

The first character of the REPLY field contains a response class code. The response class code identifies the type of response. Table 11-8 on the following page lists response classes and response class codes.

Table 11-8. Response Classes and Response Class Codes

Class	Class Code
Data return response	1
Text output response	2
Execution response	3

Data Return Response. Digi 4 Plus transmits a data return response for each inspection command (Command Code 3xx) or programming/inspection command (Command Code 5xx).

Table 11-9 shows the the REPLY field of a data return response. Notice that the REPLY field of all data return responses = (except text output responses) contains 18 characters. The REPLY field of the text output responses contains 36 characters.

Table 11-9. Data Return Responses (Reply Field)

Character Number	Composition
1	Response Class Code
2-4	Echo of Command Code
5-17	Data

Text Output Response. Digi transmits a text output response for each request text output transmission command (Command Codes 120-128). Table 11-10 shows the REPLY field of a text output response.

Table 11-10. Text Output Responses (Reply Field)

Character Number	Composition
1	Response class code (2)
2, 3...	Line of text output

Execution Response. Digi transmits an execution response to Command Codes 002, 003, 004, 005, 1xx, 2xx and 4xx. It indicates whether or not the command was correctly received and executed. The REPLY field of an execution response always contains three characters. Table 11-11 lists the execution responses.

Table 11-11. Execution Responses (REPLY Field)

Execution Response	Response Interpretation
300	Command correctly received and executed
301	Command cannot be executed at this time
302	Error in command data composition
303	Error in command data format
304	Error in command data value
320	No line available; no text output pending
330	No text output for disposition change
331	Text output stopped - restart later
332	Text output stopped - continue later
333	Text output terminated
399	Non-implemented command received

System Status Responses

When the computer sends a return system status command (Command Code 301), Digi sends a response with system status information. The REPLY field (Figure 11-8) of this message contains 18 characters. Table 11-12 shows individual REPLY field characters.

Table 11-12. System Status Responses (Reply Field Characters)

Character 1. Data return response (always 1)

Characters 2-4. Echo of command code (always 301)

Character 5. Miscellaneous status indicators

1 - Auto log
2 - Open circuit
3 - Auto log & open circuit
4 - Program mode
5 - Auto log & program mode
6 - Open circuit & program mode
7 - Auto log, open circuit & program mode
0 - None of the above

Character 6. Miscellaneous status indicators

1 - System alarm
2 - Auto search
3 - System alarm & auto search
4 - Overrange
5 - System alarm & overrange
6 - Auto search & overrange
7 - System alarm, auto search & overrange
8 - Alarm log
9 - Alarm log & system alarm
A - Auto search & alarm log
B - System alarm, auto search & alarm log
C - Overrange & alarm log
D - System alarm, overrange & alarm log
E - Auto search, overrange, & alarm log
F - System alarm, auto search, overrange & alarm log
0 - None of the above

Character 7. Text outputs pending

1 - Report 1
2 - Alarm status report
3 - Report 1 & alarm status report
4 - Accumulation totals
5 - Report 1 & accum. totals
6 - Alarm status report & accum. totals
7 - Report 1, alarm status report & accum. totals
8 - Messages
9 - Report 1 & messages
A - Alarm status report & messages
B - Report 1, alarm status report & messages
C - Accum. totals & messages
D - Report 1, accum. totals & messages
E - Alarm status report, accum. totals & messages
F - Report 1, alarm status report, accum. totals & messages
0 - None of the above

Table 11-12. System Status Responses (Reply Field Characters) - Continued

Character 8. Text outputs pending

1 - Program listing
2 - Report 4
3 - Program listing & Report 4
4 - Report 3
5 - Program listing & Report 3
6 - Report 3 & Report 4
7 - Program listing, Report 3 & Report 4
8 - Report 2
9 - Program listing & Report 2
A - Report 2 & Report 4
B - Program listing, Report 2 & Report 4
C - Report 2 & Report 3
D - Program listing, Report 2 & Report 3
E - Report 2, Report 3 & Report 4
F - Program listing, Report 2, Report 3 & Report 4
0 - None of the above

Character 9. Parameters changed since last program listing

1 - Historical buffers
2 - System config. codes
3 - Hist. buffers & system config. codes
4 - Relay latching states
5 - Hist. buffers & relay latching states
6 - System config. codes & relay latching states
7 - Hist. buffers, system config. codes & relay latching states
8 - Sequencer config. codes
9 - Hist. buffers & sequencer config. codes
A - System config. codes & sequencer config. codes
B - Hist. buffers, system config. codes & sequencer config. codes
C - Relay latching states & sequencer config. codes
D - Hist. buffers, relay latching states & sequencer config. codes
E - System config. codes, relay latching states & sequencer config. codes
F - Hist. buffers, system config. codes, relay latching states & sequencer config. codes
0 - None of the above

Character 10. Parameters changed since last program listing

1 - Channel and CALC channel parameters
2 - Messages
3 - Channel and CALC channel parameters & messages
4 - Timers and/or clock
5 - Channel and CALC channel parameters & timers and/or clock
6 - Messages & timers and/or clock
7 - Channel and CALC channel parameters, messages & timers and/or clock
8 - Constants
9 - Channel amd CALC channel parameters & constants

Character 10. Parameters changed since last program listing (cont)

A - Messages & constants
B - Channel and CALC channel parameters, messages & constants
C - Timers and/or clock & constants
D - Channel and CALC channel parameters, timers and/or clock & constants

Table 11-12. System Status Responses (Reply Field Characters) - Continued

E - Messages, timers and/or clock & constants
F - Channel and CALC channel parameters, messages, timers and/or clocks & constants
0 - None of the above

Character 11. Baud rate of communications port
0 - 110 baud
1 - 300 baud
2 - 600 baud
3 - 1200 baud
4 - 2400 baud
5 - 4800 baud
6 - 9600 baud
7 - Reserved (4800 baud)

Character 12. Reserved (always blank)

Character 13. Program mode flag
0 - Program mode disabled
1 - Operator panel in program mode
2 - Communications port in program mode

Characters 14-18. Reserved (always blank)

11.3.3 Error Handling

CXT protocol provides error checks to allow the computer to initiate and complete recovery from the following errors:

Communications Errors are are garbled command message errors. They include parity, checksum, character framing and message framing errors.

Tag Errors are command message sequence errors. The values assigned the TAG fields indicate the sequencing of command messages.

Command Code Errors are non-implemented command code transmission errors. Non-implemented command codes are all 6xx, 7xx and 8xx commands, and all undefined commands with Command Codes 0xx, 1xx, 2xx, 3xx, 4xx and 5xx.

Instruction Errors are errors transmitting incorrect data in the INSTRUCTION field of a command message, or transmitting a command at the wrong time.

Error Detection and Recovery

CXT protocol automatically checks each computer transmission for communications errors, tag errors, command code errors and instruction errors. When it detects an error, Digi either sends an error message, waits 5-seconds and de-accesses, or de-accesses immediately. You must program the computer to detect errors and initiate recovery in the ways described belopw.

Communications Errors (Computer to Digi). If the Digi detects a communications error in a command, it sends no response, but begins a 5-second time-out. If it does not receive an acceptable command by the end of the time-out, Digi automatically de-accesses and transmits no response. If the computer does not receive a response from the Digi within a specified response time-out, it repeats the command up to three times. If the

command still has not been acknowledged, Digi de-accesses; then attempts re-access. If it cannot re-access, check the system for malfunctions.

Communications Errors (Digi to Computer). If the computer detects a communications error in a Digi response, it repeats the command up to three times. If Digi still has not acknowledged the command, Digi de-accesses; then attempts re-access. If it cannot, check the system for malfunctions.

Tag Errors (Computer to Digi). If Digi detects a tag error in a computer command, it automatically de-accesses and transmits no response. If the computer does not receive a response from Digi within a specified response time-out, it repeats the command up to three times. If the Digi still does not receive a response, Digi de-accesses; then attempts re-access. If it cannot, check the system for malfunctions.

Tag Errors (Digi to Computer). If the computer detects a tag error in a Digi response, it repeats the command up to three times. If Digi still has not acknowledged the command, the Digi de-accesses; then attempts re-access. If it cannot, check the system for malfunctions.

Command Code Errors (Computer to Digi). If Digi detects a command code error in a computer command, it automatically transmits a 399 execution response (non-implemented command received). When it receives this response, the computer repeats the command up to three times. If the Digi still has not acknowledged it, make sure the computer sent the correct command code. If the code was correct, the Digi de-accesses; then attempts re-access. If it cannot, check the system for malfunctions.

Command Code Errors (Digi to Computer). If the computer detects a command code error in a Digi response, it repeats the command up to three times. If Digi still has not acknowledged it, Digi de-accesses; then attempt re-access. If it cannot, check the system for malfunctions.

Instruction Errors (Computer to Digi). If Digi detects an instruction error in a computer command, it returns an error message (an execution response indicating an error). When the computer receives an error message, it notifies the operator so the error can be corrected.

Checksum Algorithm

Use the following algorithm to calculate the checksum value for data transmissions in CXT protocol:

1. Set the 8-bit checksum initial value = 0.
2. Point to the first character of line of data to be transmitted.
3. Exclusive-or the character with checksum; set new checksum value.
4. If another character is available, get the next character and go to Step 3. If not, terminate the calculation.

The checksum is transmitted in the following way:

- o Transmit the most-significant four bits of the checksum as a hexadecimal digit (represented by ASCII characters 0-9 and A-F).
- o Transmit the least-significant four bits of the checksum as a hexadecimal digit.

The SOM character is included in the checksum; the EOM character is not.

The exclusive-or does not include the parity of the data bytes. The parity bit of each checksum character is that character's parity.

To avoid checksum calculations, transmit the CHECKSUM field of each command message as two asterisks. Digi automatically transmits two asterisks as the checksum of the response message on a transaction-by-transaction basis.

Tag Algorithm

The tag algorithm checks the TAG field of each message for proper sequencing. Command Code 000 (access command message) sets the initial value of the tag and must be in the 0-9 range. The tag of each new command message must be the next number in sequence (with 0 the next number after 9). A repeated command message must be the same as the original command message (including the tag). The tag of each response message must be the same as the tag of its command message.

11.3.4 CXT Commands and Responses Tables

Table 11-13 lists all CXT commands and responses.

The first column lists the commands. The 3-digit number is the command code. The x's (if any) represent the number of data characters or spaces that you must include in the command. The command code and the x's are the INSTRUCTION field. Remember that you must also include other fields in each command message.

The second column describes the command.

The third column contains an example of the command. It shows the data (if any) included in the command message and the exact character sequence of the INSTRUCTION field. Underscores (_) indicate spaces that must be included in the character sequence.

The fourth column contains the REPLY field of Digi's response message. Underscores (_) indicate the exact number of characters and spaces required. The first character is the response class code. The remaining characters are the response data.

Table 11-13. CXT Commands and Responses

Exception Commands

Command	Description	Example	Response
000xxxxxx	Access Digi 4 Plus	To access Digi 4 Plus with a CXT password of 150000, use Command 000150000. (See Configuration Code Address 902.)	Answer-back (Msg. 000)
001	De-access Digi 4 Plus (1)	To de-access Digi 4 Plus, use Command 001.	None
002xxxxxxxxxx	Set system clock (2)	To set the system clock (using the data entry format mmddhhmmss) for a current time of exactly 2:30 PM (14 hrs, 30 mins, 00 secs) on December 9th (month 12, day 09), use Command 0021209143000. Where: mm = month (01-12) dd = day (01-31) hh = hour (00-23) mm = minute (00-59) ss = second (00-59)	300

(1) There is no response to the de-access command.

(2) Command 002 sets the system clock for the Digi 4 Plus accessed. The clock is set whenever the seconds (ss) field of the new time is transmitted as 00 seconds. If the new time is transmitted with its seconds field reading other than 00, the new time is incremented each second until the seconds field reads 00. Then, the system clock is set to the new time. The system clocks of all Digi 4's in a multi-link system can be set simultaneously with a broadcast message.

Table 11-13. CXT Commands and Responses

Broadcast Commands

Command	Description	Example	Response
90	Broadcast time to all Digi 4 Pluses on-line.	Example: 90MMDDHHMMSS	none
91	Switch Digi 4 Plus currently on-line from TRM to CXT protocol.	To switch Digi with UID of 15 from TRM to CXT protocol, use Command 91.	See below.

Command

@ + 91 + TAG + Checksum + CR

Start of msg

Command

Tag (0 to 9)

Checksum (** if not used).

Carriage Return.

Example of 91 Command: @910**(CR)

Response

@ + UID + TAG + 1 + Answer back msg. + Checksum + CR

Start of msg

Unit Identifier

Tag (0 to 9)

Answer Back Message
(Stored at Text Address 000. 1 precedes text.)

Checksum (** if not used)

Carriage Return

Example of 91 response: @0201GENERATOR B **(CR)

Table 11-13. CXT Commands and Responses (continued)

Exception Commands (continued)

Command	Description	Example	Response
003	Suspend transmission in progress and restart from beginning later (3)	To suspend a transmission currently in progress and restart it later, use Command 003	331
004	Suspend transmission in progress and continue later (3)	To suspend a transmission currently in progress and continue it later, use Command 004	332
005	Terminate transmission in progress (3)	To terminate a transmission currently in progress, use Command 005	333
006	Start of session (4)	At the start of a multiple command, multi-drop transmission to a particular Digi 4 Plus, use Command 006	300
007	End of session (4)	At the end of a multiple command, multi-drop transmission to a particular Digi 4 Plus, use Command 007	300

(3) These commands should occur only when Command 128 (request transmission of next line) is valid. If one of these commands occurs when other direct action or program/inspection commands are allowed, an error message is returned.

(4) Commands 006 (start of session) and 007 (end of session) are used only in multi-drop applications. When multiple Digi 4s are accessed concurrently, use the start of session command at the start of a multiple command transmission to a Digi 4 Plus. After this command is received, Digi 4 Plus' RTS signal remains ON until the end of session command, or a command addressed to another Digi 4 Plus is received. Commands 006 and 007 eliminate the turnaround time otherwise required for repeatedly addressing the same Digi 4 Plus.

Table 11-13. CXT Commands and Responses (continued)

Direct Action Commands

Command	Description	Example	Response
100	Enable auto log	To enable the auto log feature, use Command 100.	300
101	Enable alarm log	To enable the alarm log feature, use Command 101.	300
102xxxxxx	Enable Program mode	To enable Program mode operation of a Digi 4 Plus that has a Program mode password of 333444, use Command 102333444.	300
103	Disable auto log	To disable the auto log feature, use Command 103.	300
104	Disable alarm log	To disable the alarm log feature, use Command 104.	300
105	Disable Program Mode	To disable Program mode operation, use Command 105.	300
106	Set Logic Address 085 TRUE (5)	To set the logic bit at Logic Address 085 TRUE, use Command 106.	300
107	Set Logic Address 086 TRUE (5)	To set the logic bit at Logic Address 086 TRUE, TRUE, use Command 107.	300
108	Set Logic Address 087 TRUE (5)	To set the logic bit at Logic Address 087 TRUE, use Command 108.	300
109	Set Logic Address 088 TRUE (5)	To set the logic bit at Logic Address 088 TRUE, use Command 109.	300
110	Set Logic Addresses 092 and 093 TRUE (4)	To set the logic bits at Logic Addresses 092 and 093 TRUE, use Command 110.	300
111	Set Logic Addresses 095 and 096 TRUE (4)	To set the logic bits at Logic Addresses 095 and 096 TRUE, use Command 111.	300

(4) See footnote (4) on previous page.
(5) These commands set the logic bits TRUE for one math scan.

Table 11-13. CXT Commands and Responses (continued)

Direct Action Commands (continued)

Command	Description	Example	Response
112	Delete transmission of first pending limit or sequencer message (6)	To delete transmission of first pending limit or sequencer message, use Command 112.	300
113	Delete transmission of first pending accumulation total (6)	To delete transmission of first pending accumulation total, use Command 113.	300
114	Delete transmission of first pending channel alarm report (6)	To delete transmission of first pending channel alarm report, use Command 114.	300
115	Delete transmission of first pending Data Report 1 (6)	To delete transmission of first pending Data Report 1, use Command 115.	300
116	Delete transmission of first pending Data Report 2 (6)	To delete transmission of first pending Data Report 2, use Command 116.	300
117	Delete transmission of first pending Data Report 3 (6)	To delete transmission of first pending Data Report 3, use Command 117.	300
118	Delete transmission of first pending Data Report 4 (6)	To delete transmission of first pending Data Report 4, use Command 118.	300
119	Delete transmission of first pending program listing (6)	To delete transmission of first pending program listing, use Command 119.	300

(6) These commands cause the first pending transmission of that type to be deleted from the pending FIFO queue. If there is no transmission pending, an error message is returned.

Table 11-13. CXT Commands and Responses (continued)

Direct Action Commands (continued)

Command	Description	Example	Response
120	Request transmission of first line of first pending limit or sequencer message	To request transmission of the first line of the first pending limit or sequencer message, use Command 120.	(7)
121	Request transmission of first line of first pending accumulation total	To request transmission of the first line of the first pending accumulation total, use Command 121.	(7)
122	Request transmission of first line of first pending channel alarm report	To request transmission of the first line of the first pending channel alarm report, use Command 122.	(7)
123	Request transmission of first line of first pending Data Report 1	To request transmission of the first line of the first pending Data Report 1, use Command 123.	(7)
124	Request transmission of first line of first pending Data Report 2	To request transmission of the first line of the first pending Data Report 2, use Command 124.	(7)
125	Request transmission of first line of first pending Data Report 3	To request transmission of the first line of the first pending Data Report 3, use Command 125.	(7)
126	Request transmission of first line of first pending Data Report 4	To request transmission of the first line of the first pending Data Report 4, use Command 126.	(7)
127	Request transmission of first line of first pending program parameter listing	To request transmission of the first line of the first pending program parameter listing, use Command 127.	(7)

(7) The request transmission commands cause the first line of the specified transmission to be the transmitted response. After the first line is transmitted, use Command 128 to request each additional line. Each transmission response begins with 2xx.

Table 11-13. CXT Commands and Responses (continued)

Direct Action Commands (continued)

Command	Description	Example	Response
128	Request transmission of next pending line of data	To request transmission of the next pending line of data, use Command 128.	(8)

(8) This command causes the next pending line of data to be transmitted. If the tag on this command is the same as the previous command, the previous line is retransmitted. Otherwise, the next pending line of data, if there is one, is transmitted. If there is no next line, the execution response 300 (end of transmission) is sent.

Table 11-13. CXT Commands and Responses (continued)

Listing Commands

Command	Description	Example	Response
200	Request historical buffer parameter listing (all historical buffers)	To request a listing of the parameters programmed for Historical Buffers 01-16, use Command 200.	(9)
201	Request channel parameter listing (all channels)	To request a listing of the parameters programmed for Channels 101-816 (including channel labels), use Command 201.	(9)
202xxxxxx	Request channel parameter listing (selected group of channels)	To request a listing of the parameters programmed for Channels 101-116 (including channel labels), use Command 202101116.	(9)
203	Request system configuration code listing (all system configuration codes)	To request a listing of the values programmed for System Configuration Codes 001-050, use Command 203.	(9)
204	Request relay latch state listing (all relay addresses)	To request a listing of the latching states programmed for Relay Addresses 101-148, use Command 204.	(9)
205	Request sequencer parameter listing (all sequencer configuration codes)	To request a listing of the parameters programmed for sequencer Configuration Codes 201-299, use Command 205.	(9)
206xxxx	Request sequencer parameter listing (selected group of sequencer configuration codes)	To request a listing of the parameters programmed for sequencer Configuration Codes 201-224, use Command 2060124.	(9)
207	Request constant parameter listing (all constants)	To request a listing of the parameters programmed for Constants 01-99, use Command 207.	(9)
208	Request system timer parameter listing (all system timers)	To request a listing of the parameters programmed for System Timers 01-16, use Command 208.	(9)
209	Request message listing (Messages 01-99)	To request a listing of programmed Messages 01 to 99 Messages 01-99, use Command 209.	(9)

(9) Each listing command sets a transmission pending indicator. This indicator tells the system that a listing has been requested. To begin transmission of the first pending listing, use Command 127. The normal response for all listing commands is 300.

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands

Command	Description	Example	Response
300	Return response data for the previously executed inspection or programming command	To return response data for the previously executed programming Command 433 (e.g., define Function Code 018 for Channel 201), use Command 300.	1433_ _201_ _ _ _ _018F
301	Return system status	To return the system status code (e.g. 301000000710), use Command 301.	1301000000710_ _ _ _
302	Return system software revision	To return the system software revision, use Command 302.	1302_S5110_V.100_ _
303	Return current date and time	To return the current date and time (e.g. month 01, day 03, hour 12, minute 30, second 10) in the mmddhhmmss format, use Command 303.	130301.0312.30.10T
403xxxxxxxx	Program new date and time	To program a new date and time (e.g. month 09, day 15, hour 23, minute 15), in the mmddhhmm format, use Command 40309152315. When this command is entered, the seconds are automatically defined as 00.	300
503xxxxxxxx	Program and return new date and time	To program and return the above example, use Command 50309152315.	150309.1523.15.00T
304	Return current year	To return the current year (e.g., 88) use Command 304.	1304_ _ _88_ _ _ _ _ _ _ _Y
404xx	Program new year	To program the new year as 89, use Command 40489.	300
504xx	Program and return new year	To program and return the above example, use Command 50489.	1504_ _ _89_ _ _ _ _ _ _ _Y

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
305	Return current day of week	To return the current user-defined day of week (e.g. Day 2), use Command 305.	1305_ _ _ _2_ _ _ _ _ _ _ _W
405x	Program new day of week	To program the day of week as Day 1, use Command 4051.	300
505x	Program and return new day of week	To program and return the above example, use Command 5051.	1505_ _ _ _1_ _ _ _ _ _ _ _W
306	Advance parameter value to next address	To advance Function Code 018 from Channel 205 to Channel 206, use Command 306.	1306_ _206_ _ _ _ _018F
406	Advance and enter parameter value in next address	To advance and enter Function Code 018 from Channel 206 to Channel 207, use Command 406.	300
506	Advance, enter and return parameter value in next address	To advance, enter and return the above example, use Command 506.	1506_ _206_ _ _ _ _018F
307	Increment and return parameter value of next address	To increment from the function code field of Channel 108 to the function code field of Channel 109 (containing Function Code 053), use Command 307.	1307_ _109_ _ _ _ _053F
308	Decrement and return parameter value of previous address	To decrement from the function code field of Channel 108 to the function code field of Channel 107 (containing Function Code 039), use Command 308.	1308_ _107_ _ _ _ _039F

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
309	Return address of accessed historical buffer	To return the address of the accessed historical buffer (Historical Buffer 05), use Command 309.	1309_ _ _05_ _ _ _ _ _ _ _ _
409xx	Access Historical Buffer xx	To access Historical Buffer 11, use Command 40911.	300
509xx	Access and return address of Historical Buffer xx	To access and return the address of the above example, use Command 50911.	1509_ _ _11_ _ _ _ _ _ _ _ _
310	Return Source 1 for accessed historical buffer	To return Source 1 (Channel Address 408) for Historical Buffer 12, use Command 310.	713101_ _12_ _ _ _ _408S
410xxx	Program Source 1 for accessed historical buffer	To program Source 1 (Channel Address 315) for Historical Buffer 12, use Command 410315.	300
510xxx	Program and return Source 1 for accessed historical buffer	To program and return Source 1 for the above example, use Command 510315.	15101_ _12_ _ _ _ _315S
311	Return Source 2 for accessed historical buffer	To return Source 2 (Logic Address 002) for Historical Buffer 12, use Command 311.	13112_ _12_ _ _ _ _002S
411xxx	Program Source 2 for accessed historical buffer	To program Source 2 (Logic Address 005) for Historical Buffer 12, use Command 411005.	300
511xxx	Program and return Source 2 for accessed historical buffer	To program and return Source 2 for the above example, use Command 511005.	15112_ _12_ _ _ _ _005S

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
312	Return accessed system timer address	To return the address of System Timer 10, use Command 312.	131210----------
412xx	Access System Timer xx	To access System Timer 11, use Command 41211.	300
512xx	Access and return address of System Timer xx	To access and return the address of the above example, use Command 51211.	151211----------
313	Return input (time interval) for the accessed system timer	To return the input (00 days, 08 hours, 00 minutes and 00 seconds) for System Timer 11 in the ddhhmmss format, use Command 313.	131311.0008.00.00I
413xxxxxxx	Program input (time interval) for the accessed system timer	To program the input for System Timer 11 as 01 days, 00 hours, 00 minutes and 0 tens-of-seconds, using the ddhhmms format, use Command 4130100000.	300
513xxxxxxx	Program and return input (time interval) for the accessed system timer	To program and return the input for the above example, use Command 5130100000.	151311.0100.00.00I
314	Return output (reset time) for the accessed system timer	To return the output (21 days, 05 hours, 30 minutes and 00 seconds) for System Timer 11 in the ddhhmmss format, use Command 314.	131411.2105.30.00O
414xxxxxxx	Program output (reset time) for the accessed system timer	To program the output for System Timer 11 as 29 days, 11 hours, 00 minutes and 0 tens-of-seconds, in the ddhhmms format, use Command 4142911000.	300
514xxxxxxx	Program and return output (reset time) for the accessed system timer	To program and return the output for the above example, use Command 5142911000.	151411.2911.00.00O

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
315	Return address of the accessed constant	To return the address for the accessed constant (Constant 05), use Command 315.	1315_ _ _05_ _ _ _ _ _ _ _
415xx	Access Constant xx	To access Constant 06, use Command 41506.	300
515xx	Access and return address of Constant xx	To access and return address of the above example, use Command 51506.	1515_ _ _06_ _ _ _ _ _ _ _
316	Return input for the accessed constant	To return the input (-6.5321) for the accessed constant (Constant 06), use Command 316.	1316_ _ _06_-6.5321I
416xxxxxxxx	Program input for the accessed constant	To program the input (4.2233) for the accessed constant (Constant 06), use Command 416_4.2233.	300
516xxxxxxxx	Program and return input for the accessed constant	To program and return the input for the above example, use Command 516_4.2233.	1516_ _ _06_ _ _ _ _4.2233I
317	Return output for the accessed constant	To return the output (100) for the accessed constant (Constant 06), use Command 317.	1317_ _ _06_ _ _ _ _100O
417xxxxxxxx	Program output for the accessed constant	To program the output (-22.455) for the accessed constant (Constant 06), use Command 417-22.455.	300
517xxxxxxxx	Program and return output for the accessed constant	To program and return the output for the above example, use Command 517-22.455.	1517_ _ _06_-22.455O

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
318	Return accessed text address	To return the address and character number (01) for the accessed text address (Text Address 101), use Command 318.	1318_ _101_ _ _ _ _ _ _01
418xxx	Access Text Address xxx	To access Text Address 024, use Command 418024.	300
518xxx	Access and return Text Address xxx	To access and return the text address and character number for the above example, use Command 518024.	1518_ _024_ _ _ _ _ _ _01

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
319	Return text for accessed text address	**Channel Labels (Text Addresses 101-816)** To display the text (TANK 1) for the accessed text address (Text Address 101), use Command 319. Note that each channel label can contain up to 8 characters. The balance of the 32-character field is filled with spaces.	1319TANK_1_ _ _ _ _ _ _etc.
		Messages (Text Addresses 000-099) To display the text (TANK 1 - TOO HOT) for the accessed text address (Text Address 033), use Command 319. Note that each message can contain up to 32 characters. The unused portion of the 32-character field is filled with spaces.	1319TANK_1_TOO_HOT_ _ _etc.
419xxxxx...	Program text for accessed text address	**Channel Labels (Text Addresses 101-816)** To define the text (PRESSURE) for the accessed text address (Text Address 108), use Command 419PRESSURE_ _. Note that each channel label can contain up to 8 characters. The balance of the 32-character field must be filled with spaces.	300
		Messages (Text Addresses 000-099) To define the text (START PUMP 1) for the accessed text address (Text Address /24), use Command 419START PUMP 1_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _. Note that each message can contain up to 32 characters. The balance of the 32 character field must be filled with spaces.	300

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
519xxxxx...	Program and return text for accessed text address	To program and return text for previous channel label example, use Command 519PRESSURE_____.	1519PRESSURE_____etc.
320	Return accessed configuration code address	To return the address for the accessed configuration code (CC 001), use Command 320.	1320__001_____C
420xxx	Access Configuration Code Address xxx	To access Configuration Code 004, use Command 420004.	300
520xxx	Access and return Configuration Code Address xxx	To access and return the configuration code address for the above example, use Command 520004.	1520__004_____C

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
321	Return value of accessed configuration code	**System Configuration Codes (CC 001-050)** To return the value (100000) for the accessed configuration code (CC 001), use Command 321.	1321_ _001_ _100000_
		Relay Latching Config. Codes (CC 101-148) To return the value (0) for the accessed configuration code (CC 110), use Command 321.	1321_ _110_ _ _ _ _ _ _0_
		Sequencer Configuration Codes (CC 201-299) To return the value (-000000) for the accessed configuration code (CC 201), use Command 321.	1321- _20100.00.00_
421xxxxxx	Program value of accessed configuration code	**System Configuration Codes (CC 001-050)** To program the value (001211) for the accessed configuration code (CC 002), use Command 421_001211.	300
		Relay Latch State Config. Codes (CC 101-148) To program the value (1) for the accessed configuration code (CC 120), use Command 421_ _ _ _ _ _1.	300
		Sequencer Configuration Codes (CC 201-299) To program the value (00.00.00) for the accessed configuration code (CC 204), use Command 421_000000.	300
521xxxxxx	Program and return value of accessed configuration code	To program and return the value of the system configuration code example above, use Command 521_001211.	1521_ _002_ _001211_

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
322	Return Input 1 for accessed sequencer configuration code	To return Input 1 (--00) for the accessed sequencer configuration code (CC 201), use Command 322.	13221_201_51.--00I
422xxxx	Program Input 1 for accessed sequencer configuration code	To program Input 1 (1-00) for the accessed sequencer configuration code (CC 201), use Command 4221-00.	300
522xxxx	Program and return Input 1 for accessed sequencer config. code	To program and return Input 1 for the above example, use Command 5221-00.	15221_201_51.1-00I
323	Return Input 2 for accessed sequencer configuration code	To return Input 2 (0011) for the accessed sequencer configuration code (CC 201), use Command 323.	13232_201_55.0011I
423xxxx	Program Input 2 for accessed sequencer configuration code	To program Input 2 (00--) for the accessed sequencer configuration code (CC 201), use Command 42300--.	300
523xxxx	Program and return Input 2 for accessed sequencer configuration code	To program and return Input 2 for the above example, use Command 52300--.	15232_201_55.00--I

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
324	Return Input 3 for accessed sequencer configuration code (CC 201), use Command 324.	To return Input 3 (0000) for the accessed sequencer configuration code	13243_201_59.0000I
424xxxx	Program Input 3 for accessed sequencer configuration code	To program Input 3 (1111) for the accessed sequencer configuration code (CC 201), use Command 4241111.	300
524xxxx	Program and return Input 3 for accessed sequencer config. code	To program and return Input 3 for the above example, use Command 5241111.	15243_201_59.1111I
325	Return Input 4 for accessed sequencer configuration code	To return Input 4 (0000) for the accessed sequencer configuration code (CC 201), use Command 325.	13254_201_63.0000I
425xxxx	Program Input 4 for accessed sequencer configuration code	To program Input 4 (0101) for the accessed sequencer configuration code (CC 201), use Command 4250101.	300
525xxxx	Program and return Input 4 for accessed sequencer config. code	To program and return Input 4 for the above example, use Command 5250101.	15254_201_63.0101I

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
326	Return Output 1 for accessed sequencer configuration code	To return Output 1 (0000) for the accessed sequencer configuration code (CC 201), use Command 326.	13221_201_01.0000O
426xxxx	Program Output 1 for accessed sequencer configuration code	To program Output 1 (1-00) for the accessed sequencer configuration code (CC 201), use Command 4261-00.	300
526xxxx	Program and return Output 1 for accessed sequencer configuration code	To program and return Output 1 for the above example, use Command 5261-00.	15261_201_01.1-00O
327	Return Output 2 for accessed sequencer configuration code	To return Output 2 (0011) for the accessed sequencer configuration code (CC 201), use Command 327.	13272_201_05.0011O
427xxxx	Program Output 2 for accessed sequencer configuration code	To program Output 2 (0000) for the accessed sequencer configuration code (CC 201), use Command 4270000.	300
527xxxx	Program and return Output 2 for accessed sequencer configuration code	To program and return Output 2 for the above example, use Command 5270000.	15272_201_05.0000O

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
328	Return Output 3 for accessed sequencer configuration code	To return Output 3 (0000) for the accessed sequencer configuration code (CC 201), use Command 328.	13283_201_09.0000O
428xxxx	Program Output 3 for accessed sequencer configuration code	To program Output 3 (1111) for the accessed sequencer configuration code (CC 201), use Command 4281111.	300
528xxxx	Program and return Output 3 for accessed sequencer configuration code	To program and return Output 3 for the above example, use Command 5281111.	15283_201_09.1111O
329	Display Output 4 for accessed sequencer configuration code	To display Output 4 (0000) for the accessed sequencer configuration code (CC 201), use Command 329.	13294_201_13.0000O
429xxxx	Program Output 4 for accessed sequencer configuration code	To define Output 4 (0101) for the accessed sequencer configuration code (CC 201), use Command 4290101.	300
529xxxx	Program and return Output 4 for accessed sequencer configuration code	To program and return Output 4 for the above example, use Command 529/101.	15294_201_13.0101O

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
330	Return Source 1 for accessed sequencer configuration code	To return Source 1 (000.1) for the accessed sequencer configuration code (CC 201), use Command 330.	13301_201_ _000.1S
430xxxx	Program Source 1 for accessed sequencer configuration code	To program Source 1 (003.1) for the accessed sequencer configuration code (CC 201), use Command 4300031.	300
530xxxx	Program and return Source 1 for accessed sequencer configuration code	To program and return Source 1 for the above example, use Command 5300031.	15301_201_ _ _003.1S
331	Return Source 2 for accessed sequencer configuration code	To return Source 2 (000.1) for the accessed sequencer configuration code (CC 201), use Command 331.	13312_201_ _ _000.1S
431xxxx	Program Source 2 for accessed sequencer configuration code	To program Source 2 (066.0) for the accessed sequencer configuration code (CC 201), use Command 4310660.	300
531xxxx	Program and return Source 1 for accessed sequencer configuration code	To program and return Source 2 for the above example, use Command 5310660.	15312_201_ _ _066.0S

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
332	Return address for for accessed channel or CALC channel(Channel 203),	To return the address for the accessed channel use Command 332.	1332_ _203_ _ _ _ _ _ _ _
432xxx	Access Channel or CALC Channel xxx	To access Channel 301 use Command 432301.	300
532xxx	Access and return address for Channel or CALC Channel xxx	To access and return the address for the above example, use Command 532301.	1532_ _301_ _ _ _ _ _ _ _
333	Return function code for accessed channel or CALC channel	To return the function code (Function Code 006) assigned to the accessed channel (Channel 301), use Command 333.	1333_ _301_ _ _ _ _006F
433xxx	Program Function Code xxx for accessed channel or CALC channel	To program a function code (Function Code 055) for the accessed channel (Channel 301), use Command 433055.	300
533xxx	Program and return Function Code xxx for accessed channel or CALC channel	To program and return the Function Code for the above example, use Command 533055.	1533_ _301_ _ _ _ _055F
334	Return decimal code for accessed channel or CALC channel	To display the decimal code (Decimal Code 00.000) for the accessed channel (Channel 301), use Command 334.	1334_ _301_ _ _0.000D
434xxxxxx	Program decimal code for accessed channel or CALC channel	To define the decimal code (Decimal Code 00.000) for the accessed channel (Channel 301), use Command 434000.00.	300
534xxxxxx	Program and return decimal code for accessed channel or CALC channel	To program and return the Decimal Code for the above example, use Command 534000.00.	1534_ _301_ _ _ _0.00D

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
335	Return Input 1 value for accessed channel or CALC channel	To return the Input 1 value (0.0000) for the accessed channel (Channel 308), use Command 335.	13351_ _308_0.0000I
435xxxxxx	Program Input 1 value for accessed channel or CALC channel	To program the Input 1 value (1.0000) for the accessed channel (Channel 308), use Command 435-1.0000.	300
535xxxxxx	Program and return Input 1 value for accessed channel or CALC channel	To program and return the Input 1 value for the above example, use Command 535-1.0000.	15351_ _308_1.0000I
336	Return Input 2 value for accessed channel or CALC channel	To return the Input 2 value (0.0000) for the accessed channel (Channel 308), use Command 336.	13362_ _308_0.0000I
436xxxxxx	Program Input 2 value for accessed channel or CALC channel	To program the Input 2 value (-5.0000) for the accessed channel (Channel 308), use Command 436-5.0000.	300
536xxxxxx	Program and return Input 2 value for accessed channel or CALC channel	To program and return the Input 2 value for the above example, use Command 536-5.0000.	15362_ _308-5.0000I

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
337	Return Input 1 calibration value for accessed channel	To return the Input 1 calibration value (0.9832) for the accessed channel (Channel 308), use Command 337.	13371_308_ _0.9832I
437	Program Input 1 calibration value as Input 1 Autocal value for accessed channel	To program the Input 1 calibration value (1.55) as the Input 1 Autocal value for the accessed channel (Channel 308), use Command 437.	300
537	Program and return Input 1 calibration value as Input 1 Autocal value for accessed channel	To program and return the Input 1 calibration value as the Input 1 Autocal value for the above example, use Command 537.	15371_308_ _ _ _1.55I
338	Return Input 2 calibration value for accessed channel	To return the Input 2 calibration value (4.3975) for the accessed channel (Channel 308), use Command 338.	13382_308_ _4.3975I
438	Program Input 2 calibration value as Input 2 Autocal value for accessed channel	To program the Input 2 calibration value (-0.05) as the Input 2 Autocal value for the accessed channel, use Command 438.	300
538	Program and return Input 2 calibration value as Input 2 Autocal value for accessed channel	To program and return the Input 2 calibration value as the Input 2 Autocal value for the above example, use Command 538.	15382_308_ _ _-0.05I

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
339	Return Limit 1 value and type for accessed channel	To return the Limit 1 value and type (50.000H) for the accessed channel (Channel 201), use Command 339.	13391_201_ _50.000H
439xxxxxx	Program new Limit 1 value for accessed channel	To program a new Limit 1 value (1.050) for the accessed channel (Channel 201), use Command 439_01050.	300
539xxxxxx	Program and return new Limit 1 value for accessed channel	To program and return the Limit 1 value for the above example, use Command 539-01050.	15391_201_ _ _1.050H
340	Return Limit 1 value and type for accessed channel	To return the Limit 1 value and type (1.050H) for the accessed channel (Channel 201), use Command 340.	13401_201_ _ _1.050H
440x	Program new Limit 1 type for accessed channel	To program a new Limit 1 type (L) for the accessed channel (Channel 201), use Command 440L.	300
540x	Program and return new Limit 1 type for accessed channel	To program and return the Limit 1 type for the above example, use Command 540L.	15401_201_ _ _1.050L

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
341	Return Limit 1, Op-Code 1 for accessed channel	To return Limit 1, Op-Code 1 (000110) for the accessed channel (Channel 201), use Command 341.	13411_201_ _0001101
441xxxxxx	Program Limit 1, Op-Code 1 for accessed channel	To program Limit 1, Op-Code 1 (201115) for the accessed channel (Channel 210), use Command 441201115.	300
541xxxxxx	Program and return Limit 1, Op-Code 1 for accessed channel	To program and return Limit 1, Op-Code 1 for the above example, use Command 541201115.	15411_210_ _2011151
342	Return Limit 1, Op-Code 2 for accessed channel	To return Limit 1, Op-Code 2 (000000) for the accessed channel (Channel 210), use Command 342.	13421_210- _0000002
442xxxxxx	Program Limit 1, Op-Code 2 for accessed channel	To program Limit 1, Op-Code 2 (001110) for the accessed channel (Channel 210), use Command 442001110.	300
542xxxxxx	Program and return Limit 1, Op-Code 2 for accessed channel	To program and return Limit 1, Op-Code 2 for the above example, use Command 542001110.	15421_ _210_ _0011102
343	Return Limit 1, Op-Code 3 for accessed channel	To display Limit 1, Op-Code 3 (000000) for the accessed channel (Channel 210), use Command 343.	13431_210_ _0000003
443xxxxxx	Program Limit 1, Op-Code 3 for accessed channel	To define Limit 1, Op-Code 3 (002404) for the accessed channel (Channel 210), use Command 443002404.	300
543xxxxxx	Program and return Limit 1, Op-Code 3 for accessed channel	To program and return Limit 1, Op-Code 3 for the above example, use Command 543002404.	15431_210_ _0024043

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
344	Return Limit 2 value and type for accessed channel	To return the Limit 2 value and type (20.000H) for the accessed channel, (Channel 201), use Command 344.	13442_201- -20.000H
444xxxxxx	Program new limit 2 value for accessed channel	To program a new Limit 2 value (-20.000) for the accessed channel (Channel 201), use Command 444-20000.	300
544xxxxxx	Program and return new Limit 2 value for accessed channel	To program and return the Limit 2 value for the above example, use Command 544-20000.	15442_201_-20.000H
345	Return Limit 2 value and type for accessed channel	To return the Limit 2 value and type (-20.000) for the accessed channel (Channel 201), use Command 345.	13452_201_-10.500H
445x	Program new Limit 2 type for accessed channel	To program a new Limit 2 Type (L) for the accessed channel (Channel 201), use Command 445L.	300
545x	Program and return new Limit 2 type for accessed channel	To program and return the limit 2 type for the above example, use Command 545L.	15452_201_-10.500L

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
346	Return Limit 2, Op-Code 1 for accessed channel	To return Limit 2, Op-Code 1 (000111) for the accessed channel (Channel 201), use Command 346.	13462_201_ _0001111
446xxxxxx	Program Limit 2, Op-Code 1 for accessed channel	To program Limit 2, Op-Code 1 (201115) for the accessed channel (Channel 210), (Channel 210), use Command 446201115.	300
546xxxxxx	Program and return Limit 2, Op-Code 1 for accessed channel	To program and return Limit 2, Op-Code 1 for the above example, use Command 546201115.	15462_210_ _2011151
347	Return Limit 2, Op-Code 2 for accessed channel	To return Limit 2, Op-Code 2 (000000) for the accessed channel (Channel 210), use Command 347.	13472_210_ _0000002
447xxxxxx	Program Limit 2, Op-Code 2 for accessed channel	To program Limit 2, Op-Code 2 (101010) for the accessed channel (Channel 210), use Command 447101010.	300
547xxxxxx	Program and return Limit 2, Op-Code 2 for accessed channel	To program and return Limit 2, Op-Code 2 for the above example, use Command 547101010.	15472_210_ _1010102
348	Return Limit 2, Op-Code 3 for accessed channel	To return Limit 2, Op-Code 3 (000000) for the accessed channel (Channel 210), use Command 348.	13482_210_ _0000003
448xxxxxx	Program Limit 2, Op-Code 3 for accessed channel	To program Limit 2, Op-Code 3 (002404) for the accessed channel (Channel 210), use Command 448002404.	300
548xxxxxx	Program and return Limit 2, Op-Code 3 for accessed channel	To program and return Limit 2, Op-Code 3 for the above example, use Command 548002404.	15482_210_ _0024043

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
349	Return Output 1 for accessed channel or CALC channel	To return Output 1 (0.0) for the accessed channel (801), use Command 349.	13491_801_ _ _ _ _0.0O
449xxxxxxx	Program Output 1 for accessed channel or CALC channel	To program Output 1 (0.00) for the accessed channel (801), use Command 449-000.00.	300
549xxxxxxx	Program and return Output 1 for accessed channel or CALC channel	To program and return Output 1 for the above example, use Command 549-000.00.	15491_801_ _ _ _0.00O
350	Return Output 2 for accessed channel or CALC channel	To return Output 2 (20.0) for the accessed channel (801), use Command 350.	13502_801_ _ _ _20.0O
450xxxxxxx	Program Output 2 for accessed channel or CALC channel	To program Output 2 (20.00) for the accessed channel (801), use Command 450-020.00.	300
550xxxxxxx	Program and return Output 2 for accessed channel or CALC channel	To program and return Output 2 for the above example, use Command 550-020.00.	15502_801_ _ _20.00O

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
351	Return Source 1 for accessed channel or CALC channel	To return Source 1 (- - -) for the accessed channel (801), use Command 351.	13511_801_ _ _ _ _- - -S
451xxx	Program Source 1 for accessed channel or CALC channel	To program Source 1 (201) for the accessed channel (801), use Command 451201.	300
551xxx	Program and return Source 1 for accessed channel or CALC channel	To program and return Source 1 for the above example, use Command 551201.	15511_801_ _ _ _ _201S
352	Return Source 2 for accessed channel or CALC channel	To return Source 2 (516) for the accessed channel (801), use Command 352.	13522_801_ _ _ _ _516S
452xxx	Program Source 2 for accessed channel or CALC channel	To program Source 2 (808) for the accessed channel (801), use Command 452808.	300
552xxx	Program and return Source 2 for accessed channel or CALC channel	To program and return Source 2 for the above example, use Command 552808.	15522_801_ _ _ _ _808S
353	Return units for accessed channel or CALC channel	To return units (P) for the accessed channel (201), use Command 353.	1353_ _201_ _ _ _ _ _ _ _P
453x	Program units for accessed channel or CALC channel	To program units (F) for the accessed channel (201), use Command 453F.	300
553x	Program and return units for accessed channel or CALC channel	To program and return units for the above example, use Command 553F.	1553_ _201_ _ _ _ _ _ _ _F

Table 11-13. CXT Commands and Responses (continued)

Inspection, Programming, Programming/Inspection Commands (continued)

Command	Description	Example	Response
354	Return accessed parameter address with value (10)	To return the address and value (105.42C) for the accessed channel (Channel 101), use Command 354.	1354_ _101_ _105.42C
454xxx	Access Parameter Address xxx	To access parameter address 000 (the always TRUE logic bit), use Command 4454000.	300
554xxx	Access parameter address xxx and return address and value (10)	To access the parameter address and return the address and value for the above example, use Command 554000.	1554_.000OPEN_ _ _ _ _

(10) For Parameter Addresses 101-816, the channel address, the channel data value and the state of the channel logic bit are returned. For Parameter Addresses 000-099, the logic address and the state of the system logic bit are returned. For parameter addresses 901-916, the logic address, the state of the system timer logic bit and the stored system parameter value (or OPEN) are returned. In all responses, the character position immediately to the left of the parameter address indicates the state of the logic bit. A decimal point in this character position indicates that the logic bit is TRUE. A blank indicates the logic bit is FALSE.

APPENDIX A - ORDER OF OPERATION

The operation cycle defines the order in which Digi 4 Plus accepts, processes and outputs analog and digital data. It has three phases:

1. Input
2. Computation (math scan)
3. Output

Input

Digi 4 Plus can accept analog and digital input data.

Analog Input Data comes from an Analog Plus or RTD Plus scanner or from an external scanner. It is held in the system input buffer until "picked up" before the next math scan.

The analog scan is 40 channels per second at 60 Hz and 33 1/3 channels per second at 50 Hz (with one channel of overhead per scan and one channel of overhead per bank). Configuration Code Addresses 001 and 002 control scanner mapping to channel addresses. Channel Address 911 stores the analog scan time.

Digi 4 Plus receives external scanner inputs at 1200 baud on the receive ports of Peripheral Ports 1 and 2. See your external scanner documentation for more information.

Digital Input Data comes from the status inputs connected to a Status Input scanner. See Section 2 for more information.

Computation

The math scan can vary from 0.30 to 2.00 seconds. The complexity of the program and the transmission of data via Peripheral Port 1 to an analog output module or relay closure affect the scan time. Channel Address 910 stores the math scan time.

Output

Digi 4 Plus outputs analog and digital data. Analog data is sent to Kaye analog output modules. Digital data is sent to relay closure modules, the master relays and the watchdog relay. Digi 4 Plus also sends messages, accumulation totals and reports to a computer, printer or CRT.

The operation cycle has eight steps. (See Figure A-1 on the following page.)

1. Digi 4 Plus reads the status inputs activated during the previous operation cycle and updates Status Input Logic Addresses 051-082.

2. Digi 4 Plus updates System Timer Logic Addresses 901-916 by comparing the programmed reset times with the system clock; updates each to its new reset time if it finds a match; and updates miscellaneous Logic Addresses 083-099.

3. Digi 4 Plus processes the system input data stored in the system input buffer since the beginning of the previous math scan and updates the corresponding channel outputs according to their assigned functions.

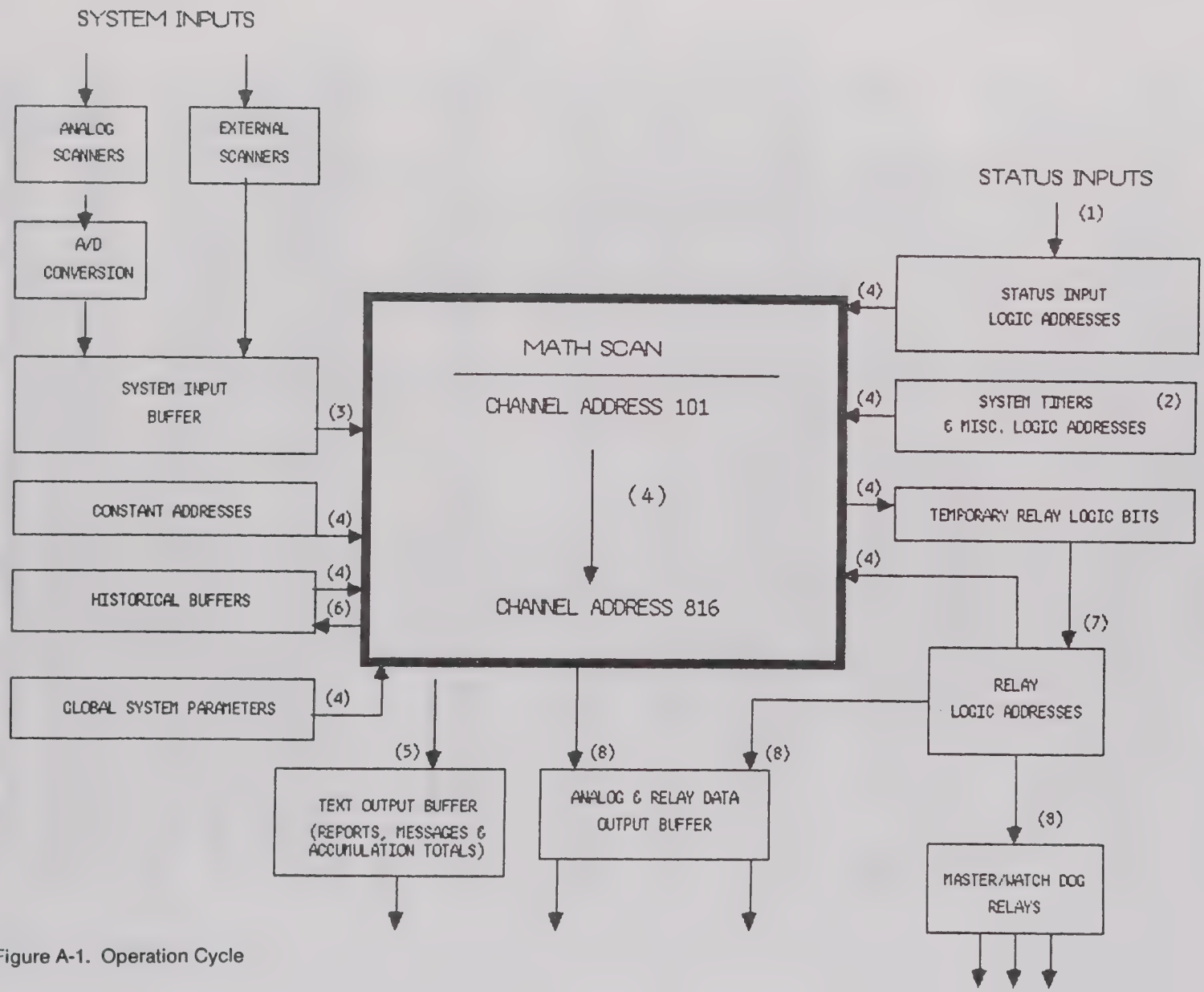


Figure A-1. Operation Cycle

4. Digi 4 Plus performs assigned functions at each CALC channel and channel address, beginning with CALC Channel Address 001, and uses data in the historical buffer as source to the historical buffer functions. Then it checks limits and sets channel logic bits as required; sets relay logic bits in the temporary relay logic buffer for assertion in Step 7; and issues limit messages and accumulation totals as specified.

5. Digi 4 Plus issues data reports and alarm status reports to the output buffer.

6. Digi 4 Plus updates historical buffers.

7. Digi 4 Plus updates Relay Logic Addresses 001-050 with the temporary logic bits set in Step 4.

8. Digi 4 Plus waits until the analog and relay data buffer is empty and loads analog and relay outputs into the output buffer for transmission to an analog output module or relay closure. Then it activates the odd and even master relays as required.

It begins the next operation cycle while analog and digital data is transmitted.

Return from a Power Outage

After a power outage, Digi 4 Plus beeps ten times (once every two seconds). Then it executes 5 additional steps before resuming the routine operation cycle.

9. Digi 4 Plus clears the system input buffer. It completes one local analog scan but processes no external scanner inputs.

10. Digi 4 Plus updates the reset time of each system timer and, if necessary, sets the corresponding timer logic output. It sets the power-on logic bit (stored at Logic Address 084) true for one math scan.

11. Digi 4 Plus clears all status inputs.

12. Digi 4 Plus loads the relay output buffer for transmission to the external relay banks, according to the latching bits stored at Configuration Addresses 101-148. It clears all output relay bits whose latch bit is off.

13. Digi 4 Plus waits 0.1 seconds after the Relay Data Buffer empties and then resumes the normal operation cycle at Step 1.

APPENDIX B - WARRANTY

KAYE INSTRUMENTS, INC.
EQUIPMENT LIMITED WARRANTY

TO WHOM GIVEN:

Kaye Instruments, Inc. (Kaye) extends this warranty only to the original non-consumer purchaser of its equipment; IT DOES NOT EXTEND TO CONSUMER PURCHASERS FOR PERSONAL, FAMILY OR HOUSEHOLD PURPOSES.

COVERAGE AND LENGTH OF WARRANTY:

1. **New Equipment**: All new Kaye equipment, except thermocouples and RTD probes, is warranted to be free from manufacturing and material defects for a period of one (1) year after shipment.

2. **Thermocouples, RTD Probes, Spare Parts and Repairs**: New Kaye thermocouples and RTD probes, and Kaye spare parts for and repairs to Kaye equipment are warranted to be free from manufacturing and material defects for a period of ninety (90) days after shipment.

3. **Non-Standard Kaye Products**: Equipment provided by Kaye, together with a Kaye system, but which are not standard Kaye products (e.g., magnetic tape recorders, paper tape punches and computers), are warranted by Kaye for a period of thirty (30) days after shipment. If the manufacturer of such equipment provides a longer warranty, Kaye will, if possible, pass this warranty on to its customers.

4. **Modifications**: Modifications to Kaye equipment performed by authorized Kaye service representatives that increase the performance or capability of that equipment are warranted free from manufacturing and material defects for the following period:

   a. Six (6) months from the date of shipment, or the balance of the original new equipment warranty, whichever is longer, for modifications performed at the Kaye Instruments Factory Service Center in Bedford, MA.

   b. Ninety (90) days from the date of shipment, or the balance of the original new equipment warranty, whichever is longer, for modifications performed at any other location.

WARRANTY PROCEDURES:

1. **What Kaye Will Do**: Any equipment or spare parts purchased from Kaye that become defective during the relevant period, or repairs or modifications done by authorized Kaye service representatives that fail during the relevant period, will be repaired or replaced at the customer's site or at the Kaye Instruments plant in Bedford, MA, at Kaye's option.

2. **Procedure for Claims**: If a customer believes a defect has occurred under this warranty, the customer should contact the Kaye Instruments Customer Service Department, which will provide instructions as to the procedure to be followed. Return authorization must be obtained from the Customer Service Department prior to returning any equipment for repair. Equipment returned to Kaye for repair must have shipping charges prepaid and must be accompanied by documentation explaining the reason for

repair. Any repairs performed by Kaye with respect to defects not covered by this warranty will be subject to time and materials charges at Kaye's standard rates.

DISCLAIMER:

1. **Misuse of Products:** This warranty is void if the product has been damaged by accident, unreasonable use, negligence, intentional harm, improper assembly or has been subject to unusual physical or electrical stress or has been modified without Kaye's approval.

2. **Changes to Software:** This warranty is void if changes have been made to the software. The software cannot be duplicated for unauthorized use.

3. **Limitation of Other Warranties; Limitation of Liability:** THE EQUIPMENT LIMITED WARRANTY SET FORTH HEREIN IS EXCLUSIVE AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE. STATEMENTS CONTAINED IN ANY KAYE LITERATURE, AND ANYTHING THAT ANY KAYE EMPLOYEE, REPRESENTATIVE OR DEALER MAY HAVE REPRESENTED TO YOU DO NOT CONSTITUTE A WARRANTY BY KAYE. ALL LIABILITIES OR OBLIGATIONS OF KAYE FOR DAMAGES OCCURRING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF KAYE PRODUCTS ARE LIMITED TO THOSE CONTAINED IN THIS WARRANTY, AND KAYE SHALL NOT BE LIABLE FOR ANY OTHER DAMAGES OR EXPENSES, INCLUDING CONSEQUENTIAL OR INCIDENTAL DAMAGES.

Address and Telephone for Claims:

Customer Service Department
Kaye Instruments, Inc.
15 DeAngelo Drive
Bedford, Massachusetts 01730

Telephone: (617)275-0300, (800)343-4624
FAX: (617)275-9024

KAYE
KAYE
KAYE

COMPRESSOR EFFICIENCY FUNCTION

A DESCRIPTION OF THE COMPRESSOR EFFICIENCY FUNCTION

Document No: M4137
First Edition - Rev. 1
July, 1990
Printed in USA

Copyright -1984
Kaye Instruments, Inc.
15 DeAngelo Drive
Bedford, MA 01730
Telephone: (617) 275-0300
(800) 343-4624
FAX: 617-275-9024

TABLE OF CONTENTS

1.0 GENERAL INFORMATION 1

2.0 COMPUTATION OF THE COMPRESSOR EFFICIENCY 2

2.1 Molal Density 2

2.2 Molal Enthalpy 7

2.3 Molal Entropy 11

2.4 Isentropic Compressor Efficiency 13

2.5 Output Values 15

3.0 PROGRAMMING THE COMPRESSOR EFFICIENCY FUNCTION ... 17

4.0 APPLICATION EXAMPLE 19

LIST OF FIGURES

Figure 1. Program Listing of Compressor Efficiency Function..... 22

Figure 2. Data Output by Compressor Efficiency Function..... 23

LIST OF TABLES

Table 1. Constants For The Benedict-Webb-Rubin Equation Of State For Natural Gas Mixtures 3

Table 2. Constants For The Ideal Enthalpy And Ideal Entropy Of Natural Gas Mixtures 8

Table 3. Summary Of Compressor Efficiency Function..... 18

Table A. Universal Gas Constants And Specific Gas Constants..... A-1

INTRODUCTION

This document describes the operation of the Compressor Efficiency Function. The Compressor Efficiency Function monitors the inlet and outlet gas states of a compressor and calculates its efficiency.

- Section 1 describes the Compressor Efficiency Function.
- Section 2 explains how to calculate the compressor efficiency.
- Section 3 explains how to program the Compressor Efficiency Function.
- Section 4 contains an application example.

The Compressor Efficiency Function combined with the PID, Sequencer and standard Digi 4 Functions constitutes the Compressor/Controller system. For a description of how the Digi 4 system operates, refer to the Digi 4 Monitor/Control System User's Guide (Document M4121). For a description of the PID Control Function Set refer to Document M4124. For a description of the Sequencer Function, refer to Document M4131.

1.0 GENERAL INFORMATION

The Compressor Efficiency Function monitors the inlet and outlet gas states of a compressor and calculates its efficiency. The Compressor Efficiency Function, combined with the control and alarming capabilities of the Digi 4, provides a powerful on-line tool for analyzing and optimizing the operation of the compressor. For example, a decrease in the efficiency of a compressor could signal overheating in a piston or a failing valve. The Digi 4 can be programmed to generate a message, turn on a relay or signal an alarm whenever the compressor efficiency falls below a user-defined value. This software can also be used to indicate the optimum operating points, i.e., temperature, pressure, etc.

The Compressor/Controller computes the isentropic efficiency of a natural gas compression process based on the Benedict-Webb-Rubin equation of state and the procedures of the AGA Mark 2 Program described in Reference 1. In addition to the isentropic compression efficiency, the function also computes the inlet density, enthalpy and entropy; the exit density, enthalpy and entropy; the temperature and enthalpy of the isentropic exit state based on the measured inlet pressure and temperature; the measured exit pressure and temperature; and the mol fractions of up to ten component gases.

The math functions of Digi 4 can be used to compute other parameters in combination with those computed by the Compressor Efficiency Function. For example, an overall efficiency can be computed by multiplying the isentropic efficiency by a mechanical efficiency. The flow can be calculated using one of the orifice meter functions and total power can be computed by multiplying the flow by the actual work done on the gas. Operating parameters such as the pressure ratio and temperature ratio can be computed using the divide function. Actual density of the mixture can be computed by multiplying the molal density by the molecular weight.

2.0 COMPUTATION OF THE COMPRESSOR EFFICIENCY

In order to avoid confusion with constants used elsewhere in the Digi 4 documentation, the eight constants of the Benedict-Webb-Rubin equation will be called C_{1j} to C_{8j}, the four constants in the ideal enthalpy function will be called C_{H1j} to C_{H4j} and the five constants in the ideal entropy function will be called C_{S1j} to C_{S5j}. Table 1 gives the values of the eight constants of the Benedict-Webb-Rubin equation and Table 2 gives the constants for the ideal enthalpy and ideal entropy for each of the ten gases for which Function 175 of Digi 4 has been programmed. The corresponding symbols used in the Mark-2 Program (Reference 1) are given in Table 1 and Table 2 enclosed by parenthesis.

2.1 MOLAL DENSITY

Because the error in molal density introduced by the linear approximation of the C_1 term (B_o term in Reference 1) can exceed one percent in typical natural gas compositions at higher pressures, the more complex Lorenz form is used in equation (1) and in the firmware of Digi 4. The basic Benedict-Webb-Rubin equation of state is given as equation (9) and the constants in that equation are defined by equations (1) to (8). The values of the individual constants, C_{ij}, are given in Table 1 for the ten gases included in the Digi 4 firmware and X_i (or X_j) is the mol fraction of each gas component in the mixture.

Table 1. Constants for the Benedict-Webb-Rubin Equation of State for Natural Gas Mixtures

(j)	(1) CO_2	(2) Nitrogen	(3) Methane	(4) Ethane	(5) Propane
C_{1j} (B_o)	0.542949	0.733681	0.682401	1.00554	1.55884
C_{2j} (A_o)	7450.60	4497.21	6995.25	15670.7	25915.4
C_{3j} (C_o) x 10^{-6}	950.675	71.9574	275.763	2194.27	6209.93
C_{4j} (b)	1.35291	0.508495	0.867325	2.85393	5.77355
C_{5j} (a)	10572.48	900.15	2984.12	20850.3	57248.0
C_{6j} (c) x 10^{-6}	1915.904	107.276	498.106	6413.14	25247.8
C_{7j} (α)	0.287166	1.19848	0.511172	1.00044	2.49577
C_{8j} (Υ)	1.181902	1.92462	1.53961	3.02790	5.64524

(j)	(6) i-Butane	(7) n-Butane	(8) i-Pentane	(9) n-Pentane	(10) n-Hexane
C_{1j} (B_o)	2.20329	1.99211	2.56386	2.51096	2.84835
C_{2j} (A_1)	38587.4	38029.6	48253.6	45928.8	54443.4
C_{3j} (C_o) x 10^{-6}	10384.7	12130.5	21336.7	25917.2	40556.2
C_{4j} (b)	10.8890	10.2636	17.1441	17.1441	28.0032
C_{5j} (a)	117047.	113705.	226902.	246148.	429901.
C_{6j} (c) x 10^{-6}	55977.7	61925.6	136052.	161306.	296077.
C_{7j} (α)	4.41496	4.52693	6.98777	7.43992	11.5539
C_{8j} (Υ)	8.72447	8.72447	11.8807	12.1886	17.1115

$$C_1 = \frac{1}{8} \sum_{i=1}^{10} \sum_{j=1}^{10} X_i X_j \, [(C_{1i})^{1/3} + (C_{1j})^{1/3}]^3 \tag{1}$$

$$C_2 = [\sum_{i-1}^{10} X_i (C_{2i})^{1/2}]^2 \tag{2}$$

$$C_3 = [\sum_{i=1}^{10} X_i (C_{3i})^{1/2}]^2 \tag{3}$$

$$C_4 = [\sum_{i=1}^{10} X_i (C_{4i})^{1/3}]^3 \tag{4}$$

$$C_5 = [\sum_{i=1}^{10} X_i (C_{5i})^{1/3}]^3 \tag{5}$$

$$C_6 = [\sum_{i=1}^{10} X_i (C_{6i})^{1/3}]^3 \tag{6}$$

$$C_7 = [\sum_{i=1}^{10} X_i (C_{7i})^{1/3}]^3 \tag{7}$$

$$C_8 = [\sum_{i=1}^{10} X_i (C_{8i})^{1/2}]^2 \tag{8}$$

$$P_e = RT\rho_e + (C_1RT - C_2 - C_3T^{-2})\rho e^2$$
$$+ (C_4RT - C_5)\rho_e^{\ 3} + C_5C_7\rho_e^{\ 6}$$
$$+ (C_6T^{-2}\rho_e^{\ 3})\ (1 + C_8\rho_e^{\ 2})\ \exp(-C_8\rho_e^{\ 2}) \qquad (9)$$

The values of the constants in Table 1 are appropriate when P_e in equation (9) is the absolute pressure in units of psia, T is the absolute temperature in units of degrees Rankine, ρ_e is the molal density in units of lb-mol/ft^3 and R is the universal gas constant in units of (psia) (ft)^3/lb-mol/°R. The value of R derived from the Handbook of Chemistry and Physics (Reference 2) in those units and given in Table A (Appendix A) is 10.7315 and the value used in the AGA Mark-2 Program (Reference 1) is 10.7335. In order to have exact agreement between the values of the properties calculated by Digi 4 and those calculated by the Mark-2 Program (Reference 1), the value 10.7335 is used for R in Function 175.

Because pressure and temperature are measured properties of the gas, equation (9) must be solved iteratively for the value of molal density. The symbol P_e is used to indicate that the pressure calculated by equation (9) is the estimated value based on the current estimate of molal density, ρ_e. The operation of Digi 4 has an inherent interactive procedure because there are typically several math scans for each scan of analog inputs. On each math scan the estimate of molal density is improved based on the current pressure error and the current value of the partial derivative of pressure with molal density at constant temperature. The current pressure error is the difference between the measured pressure and the pressure calculated by equation (9).

The partial derivative of pressure with molal density at constant temperature is given by equation (10).

$$\frac{\partial P}{\partial \rho} = RT + 2\,(C_1RT - C_2 - C_3T^{-2})\rho$$

$$+ 3\,(C_4RT - C_5)\,\rho^2 + 6\,C_5C_7\,\rho^5$$

$$+ C_6T^{-2}\,\rho^2\,[\,3 + C_8\,\rho^2(3 - 2\,C_8\,\rho^2)]\exp(-C_8\,\rho^2) \qquad (10)$$

If the value of measured pressure changes such that the difference between the measured pressure and the current value of estimated pressure is greater than ten percent of the measured pressure, the molal density is estimated by the perfect gas relation given in equation (11); otherwise the new estimate of molal density is equal to the previous value calculated by equation (13).

The calculation procedure on each math scan is as follows:

1) If $(P - P_e)/P \geq 0.1$

$$\rho_e = \frac{P}{RT} \qquad (11)$$

If $(P - P_e)/P < 0.1$

$$\rho_e = \rho \qquad (12)$$

2) Calculate P_e from equation (9).

3) Calculate ($\partial P/\partial \rho$) from equation (10).

4) Determine a new value of the molal density, ρ , from equation (13).

$$\rho = \rho_e + (P - P_e)/(\partial P/\partial \rho) \qquad (13)$$

Function 175 has pressure and temperature input values for two states corresponding to the inlet and exit states of a compression process. The procedure described above is employed to calculate the molal density at the inlet state, ρ_1 , corresponding to the inlet pressure, P_1, and the inlet temperature, t_1, and the molal density at the exit state, ρ_2 , corresponding to the exit pressure, P_2, and the exit temperature, t_2. Once the molal densities are determined, it is possible to calculate the molal enthalpy and molal entropy at each state. The inlet temperatures are in degrees Fahrenheit and must be converted to degrees Rankine by adding 459.7.

2.2 MOLAL ENTHALPY

The ideal molal enthalpy depends only on the gas composition and the temperature. Equation (18) gives the ideal molal enthalpy for natural gas where the constants C_{H1}, C_{H2}, C_{H3} and C_{H4} are given by equations (14) to (17) and the constants C_{Hij} given in Table 2 are the A_i, B_i, C_i, D_i constants given on page 23 of Reference 1.

Table 2. Constants for the Ideal Enthalpy and Ideal Entropy of Natural Gas Mixtures

(j)	(1) CO_2	(2) Nitrogen	(3) Methane	(4) Ethane	(5) Propane
C_{H1j} (A)	3357.850	3192.549	3667.566	4213.513	5048.364
C_{H2j} (B)	8.437375	6.939299	8.188628	11.37472	15.47086
C_{H3j} (C) x 10^6	3048.522	99.45623	2159.429	8138.667	13740.59
C_{H4j} (D) x 10^8	-78.90409	0.0	189.7342	15.67356	-61.82274
C_{S1j} (AM) x 10^4	16.6235	-7.29581	22.0944	70.0856	141.853
C_{S2j} (BM) x 10^8	184.899	67.4198	353.610	654.187	739.241
C_{S3j} (CM) x 10^{12}	-1043.88	-173.862	-1518.74	-3433.27	-4298.39
C_{S4j} (DM) x 10^{16}	1808.06	155.867	2229.94	5697.74	7205.53
C_{S5j} (EM)	18.6528	16.7820	16.2326	19.8766	23.2070

(j)	(6) i-Butane	(7) n=Butane	(8) i=Pentane	(9) n-Pentane	(10) n=Hexane
C_{H1j} (A)	6010.436	6654.752	7469.397	8014.650	9482.900
C_{H2j} (B)	20.43050	20.80869	24.90475	25.84214	29.2961
C_{H3j} (C) x 10^6	17684.44	16552.35	22475.60	19550.60	30243.87
C_{H4j} (D) x 10^8	19.84045	55.49386	-79.62818	199.4913	-723.3777
C_{S1j} (AM) x 10^4	234.584	222.852	297.084	300.618	379.679
C_{S2j} (BM) x 10^8	692.888	709.843	840.202	709.312	680.885
C_{S3j} (CM) x 10^{12}	-4819.47	-4707.56	-5978.76	-5178.09	-5475.68
C_{S4j} (DM) x 10^{16}	8513.23	8188.20	10701.6	9114.22	9693.75
C_{S5j} (EM)	25.1039	26.5000	29.2068	29.6787	32.9175

$$C_{H1} = \sum_{j=1}^{10} X_j \, C_{H1j} \tag{14}$$

$$C_{H2} = \sum_{j=1}^{10} X_j \, C_{H2j} \tag{15}$$

$$C_{H3} = \sum_{j=1}^{10} X_j \, C_{H3j} \tag{16}$$

$$C_{H4} = \sum_{j=1}^{10} X_j \, C_{H4j} \tag{17}$$

$$H_o = C_{H1} + C_{H2}t + C_{H3}t^2 + C_{H4}t^3 \tag{18}$$

The values of the C_{Hij} constants in Table 2 are appropriate when t is the temperature in degrees Fahrenheit and H_o is the enthalpy in BTU/lb-mol. The deviation of the enthalpy from the ideal value at the same temperature is a function of the temperature and the molal density according to equation (19).

$$\Delta H = (C_1RT - 2\,C_2 - 4\,C_3/T^2)\rho$$

$$+ (C_4RT - \frac{3}{2}\,C_5)\,\rho^2 + (\frac{6}{5}\,C_5C_7)\,\rho^5$$

$$+ (C_6T^{-2}\,\rho^2)\,\frac{3}{C_8}\,\rho^{-2} + (C_8\,\rho^2 - \frac{3}{C_8}\,\rho^{-2} - \frac{1}{2})\exp(-C_8\,\rho)^2 \qquad (19)$$

The units of enthalpy in equation (19) would be in (psia)ft^3/lb-mol as written. In order to have exact agreement between the calculations of Digi 4 and the Mark-2 Program (Reference 1), the value of enthalpy difference in equation (19) is multiplied by 0.18514 to convert the value to BTU/lb-mol before adding it to the ideal enthalpy to obtain the total enthalpy per pound mol as given in equation (20).

$$H = H_0 + 0.18514\,\Delta H \qquad (20)$$

Equations (18), (19) and (20) are employed to compute the molal enthalpy at the inlet state, H_1, based on the temperature at inlet, t_1, and the molal density at inlet, ρ_1 , and the molal enthalpy at the exit state, H_2, based on the temperature at exit, t_2, and the molal density at exit, ρ_2.

2.3 MOLAL ENTROPY

The ideal molal entropy also depends only on the gas composition and the temperature. Equation (27) gives the ideal molal entropy for natural gas where the constants C_{S1}, C_{S2}, C_{S3}, C_{S4} and C_{S5} are given by equations (21) to (25) and the molecular weight is given by equation (26). The constants C_{Sij} given in Table 2 are the A_i, B_i, C_i, D_i, E_i constants given on page 24 of Reference 1 multipled by the molecular weights, M_i, which are given in Table A (Appendix A).

$$C_{S1} = \sum_{j=1}^{10} X_j C_{S1j} \tag{21}$$

$$C_{S2} = \sum_{j=1}^{10} X_j C_{S2j} \tag{22}$$

$$C_{S3} = \sum_{j=1}^{10} X_j C_{S3j} \tag{23}$$

$$C_{S4} = \sum_{j=1}^{10} X_j C_{S4j} \tag{24}$$

$$C_{S5} = \sum_{j=1}^{10} X_j C_{S5j} \tag{25}$$

$$M = \sum_{j=1}^{10} X_j M_j \tag{26}$$

$$S_o = [C_{S1}t + C_{S2}t^2 + C_{S3}t^3 + C_{S4}t^4 + C_{S5}\log_{10}(t + 459.7)] \quad (27)$$

There are two terms to be subtracted from the ideal entropy to obtain the value of entropy at any given state. The first term, S_p, relates the pressure effect to a reference pressure, P_s, according to equation (28).

$$S_p = R \sum_{i=1}^{10} X_i \ln \left[\frac{X_i \rho RT}{P_s} \right] \quad (28)$$

Using 10.7335 psia-ft^3/lb-mol/°R as the value of R, 14.696 psia as the value of P_s and 0.18514 as the factor to convert psia-ft^3 to BTU, equation (28) may be re-written as in equation (29), where S_p is in BTU/lb-mol/°R, ρ is in lb-mol/ft^3 and T is in °R.

$$S_p = 1.9872 \ln(0.73037\ \rho T) + 1.9872 \sum_{i=1}^{10} X_i \ln (X_i) \quad (29)$$

The second deviation term, ΔS , is based on the effects of pressure variations at constant temperature and is given by equation (30).

$$\Delta S = (C_1 R + 2C_3 T^{-3})\ \rho + \frac{1}{2} C_4 R\ \rho^2$$

$$- (2C_6 T^{-3}\ \rho^2)[\ \frac{1}{C_8}\ \rho^{-2} - (\ \frac{1}{C_8}\ \rho^{-2} + \frac{1}{2}\ )\exp(-C_8\ \rho^2)] \quad (30)$$

The value of ΔS in equation (30) must be multiplied by 0.18514 to convert psia-ft^3 to Btu. The value of entropy at any state is given by equation (31) where S_o is given by equation (27), S_p by equation (29) and ΔS by equation (30).

$$S = S_o - S_p - 0.18514\ \Delta S \tag{31}$$

Equations (29), (30) and (31) are employed to compute the molal entropy at the inlet state, S_1, based on the temperature at inlet, t_1 and the molal density at inlet, ρ_1, and the molal entropy at the exit state, S_2, based on the temperature at exit, t_2, and the molal density at exit, ρ_2.

2.4 ISENTROPIC COMPRESSOR EFFICIENCY

In order to compute the isentropic compressor efficiency it is necessary to determine the molal enthalpy at the exit state which would have resulted from an isentropic compression process. That ideal exit state is called the isentropic exit state, and it is defined as having a pressure equal to the exit pressure, P_2, and a molal entropy equal to the inlet molal entropy, S_1. The temperature of the isentropic exit state, T_{2s}, can be determined by the iterative process described below. The molal density and the molal enthalpy at the isentropic exit state can be computed by the procedures of sections 2.1 and 2.2 once the temperature is determined, because the pressure is already known.

In a constant pressure process, the ratio of the change in enthalpy to the change in temperature is called the specific heat at constant pressure. The specific heat at constant pressure is also equal to the change in entropy divided by the log of the temperature ratio in such a process. These relations and the fact that the entropy at the ideal exit state is equal to the entropy at the inlet, S_1, are used in deriving equations (32) and (33).

$$C_p = \frac{H_2 - H_{2s}}{T_2 - T_{2s}} \tag{32}$$

$$T_{2s} = T_2 \exp[(S_1 - S_2)/C_p] \tag{33}$$

The first time Function 175 is executed, there will be no values in memory for T_{2s} or H_{2s}, so the specific heat at constant pressure cannot be determined by equation (32). Also, if the measured values should change suddenly, the value of T_{2s} in memory might not lie between the values of T_1 and T_2 or the value of H_{2s} might not lie between the values of H_1 and H_2, both of which are necessary conditions for a valid solution. In either of these cases, a constant value of C_p, which may be entered by the operator, is substituted in equation (33). If no value is entered for this substitute value of specific heat, C_{po}, a value of 8.0 Btu/lb-mol/°R is used.

The computation procedure is as follows:

1) If T_{2s} is greater than T_2 or less than T_1; or if H_{2s} is greater than H_2 or less than H_1:

$$C_p = C_{po}$$

2) If T_{2s} is equal to or greater than T_1 and equal to or less than T_2 and H_{2s} is equal to or greater than H_1 and equal to or less than H_2, compute C_p by equation (32).

3) Compute a new value of T_{2s} by equation (33).

4) Compute the value of molal density at isentropic exit state, ρ_{2s}, using T_{2s}, P_2 and equations (9) through (13).

5) Compute the value of molal enthalpy at the isentropic exit state, H_{2s}, using T_{2s}, ρ_{2s} and equations (18) through (20).

6) Compute the isentropic efficiency according to equation (34).

$$\eta_i = \frac{H_{2s}-H_1}{H_2-H_1} \tag{34}$$

The actual work done on the gas, W_a, in Ft-lbf/lbm is given by equation (35) where M is the molecular weight of the mixture calculated by equation (26).

$$W_a = \frac{778.17\ (H_2-H_1)}{M} \tag{35}$$

2.5 OUTPUT VALUES

The value of isentropic compression efficiency computed by equation (34) is displayed as the data of the channel where Function 175 is assigned and the actual work done on each pound of the gas, W_a, is displayed at the next higher channel. The molecular weight of the mixture computed by equation (26) is displayed at the third channel. The next seven channels display, in order, the molal density, ρ_1, and compressibility factor, Z_1, of the inlet state, the molal density, ρ_2 and compressibility factor, Z_2 of the outlet state, the molal density, ρ_b, and compressibility factor, Z_b, of a reference or base state, and the Specific Gravity of the mixture at the base state, G_b.

Source 2 of each of the ten channels which operate with Function 175 are locations of the mol fractions of the ten gases given in Tables 1 and 2 in the order they are listed there. Source 1 of the first seven channels specify in order the locations of the inlet pressure, P_1, inlet temperature, t_1, exit pressure, P_2, exit temperature, t_2, base pressure, P_b, base temperature, t_b, and the specific volume of air at base conditions, V_{ab}. Source 1 of the eighth channel is the override value of the specific heat at constant pressure, Cp_o. Table 3 on page 18 gives a summary of the parameters of Function 175.

The compressibility factors are computed by equations (36) to (38) where ρ_1, ρ_2 and ρ_b are the molal densities computed for the pressures P_1, P_2 and P_b and the temperatures T_1, T_2 and T_b according to the procedure of Section 2.1.

$$Z_1 = \frac{P_1}{RT_1 \rho_1} \tag{36}$$

$$Z_2 = \frac{P_2}{RT_2 \rho_2} \tag{37}$$

$$Z_b = \frac{P_b}{RT_b \rho_b} \tag{38}$$

The specific gravity of the mixture at base conditions, G_b, is given by equation (39), where the specific volume of air at base conditions, V_{ab}, is an input value.

$$G_b = V_{ab} M \rho_b \tag{39}$$

3.0 HOW TO PROGRAM THE COMPRESSOR EFFICIENCY FUNCTION

How does the Compressor Efficiency Function operate?
The Compressor Efficiency Function requires ten adjacent Channel Addresses. When you assign Function Code 175 to a Channel, the system automatically assigns Function Codes 201, 202, 203, 204, 205, 206, 207, 208 and 209 to the next nine higher addressed Channels. Digi 4 will not accept a Function Code 175 at a Channel unless the next nine higher addressed Channels have a Function Code of 000.

Which parameters must be specified when Function Code 175 is assigned?
Table 3 summarizes Function Code 175; it lists the specific Channel assignments and the output data at each Channel Address.

If the input data is a measured value, e.g., the inlet pressure, the address of the channel measuring the pressure should be assigned to the source parameter. For example, if the input pressure is measured at Channel Address 103, Source 1 at the first channel should be 103.

If the input data is a constant, e.g., the base temperature, the source parameter can be assigned a value of 000 and the constant can be entered at the corresponding Input parameter. For example, if the base temperature is 60.00 degrees F, Source 1 at the sixth channel can be assigned a value of 000 and 60.00 can be entered at the Input 1 parameter.

The output data is function, not source, related. That is, the output data displayed at each Channel Address is calculated based on all of the input source data, not just the input source data at the Channel Address where it is displayed. The decimal at the first channel defaults to 0.0; the decimal at all other channels defaults to the rightmost position (00000.) unless redefined in the decimal code.

Table 3. Summary of Compressor Efficiency Function

Channel Address	Function Code	Source 1*	Source 2**	Channel Output Data
nnn	175	Inlet Pressure (P_1) in psia	Mol% CO_2	Value of Isentropic Compression Efficiency Default decimal: 0000.0
nnn+1	201	Inlet Temperature (T_1) Degrees F	Mol% Nitrogen	Work done on each pound of the gas, in Ft-lbf/lbm.***
nnn+2	202	Exit Pressure (P_2) in psia	Mol% Methane	Molecular weight of the mixture in lbm/lb-mol.
nnn+3	203	Exit Temperature (T_2) Degrees F	Mol% Ethane	Molal density of inlet state in Ft^3/lb-mol
nnn+4	204	Base Pressure (P_b) in psia	Mol% Propane	Compressibility factor of inlet state
nnn+5	205	Base Temperature (T_b) Degrees F	Mol% i-Butane	Molal density of exit state in Ft^3/lb-mol
nnn+6	206	Specific volume of air at base conditions, in Ft^3/lbm (V_{ab} Ft^3/lb)	Mol% n-Butane	Compressibility factor of exit state
nnn+7	207	Specific heat at constant pressure, in BTU/lb-Mol/R (C_{po} Btu/lb-mol-R) 8.0 BTU/lb-mol/°R is default value.	Mol% i-Pentane	Molal density of base state, in Ft^3/lb-mol
nnn+8	208	---	Mol% n-Pentane	Compressibility factor of base state
nnn+9	209	---	Mol% n-Hexane	Specific gravity of mixture at base state

* Source 1 specifies the address of the data. If the data is calculated by the system, Source 1 is a channel address. If the data is a constant, Source 1 can be a constant address or 000. When Source 1 is 000, the constant can be programmed at the Input 1 parameter.

** Source 2 specifies the address of the data. If the data is calculated by the system, Source 2 is a channel address. If the data is a constant, Source 2 can be a constant address or 000. When Source 2 is 000, the constant can be programmed at the Input 2 parameter.

*** The decimal in the output data at Channels nnn+1 to nnn+9 defaults to the rightmost position (00000.) unless redefined in the decimal code.

4.0 APPLICATION EXAMPLE

The following example illustrates how the compressor efficiency function operates. The values for the inlet pressure and temperature, the exit pressure and temperature, the base pressure and temperature, the specific volume of air, the specific heat at constant pressure and the 10 gases are given as constants.

Inlet Pressure (psia) = 516.10
Inlet Temperature (F) = 36.00
Exit Pressure (psia) = 812.5
Exit Temperature (F) = 113.3
Base Pressure (psia) = 14.730
Base Temperature (F) = 60.00

Specific volume of air at base conditions (Ft^3/lb) = 13.063
Specific heat at constant pressure (Btu/lb-mol-R) = 8.0 (default)

Carbon Dioxide	= .100	I-Butane	= .110
Nitrogen	= 9.470	N-Butane	= .210
Methane	= 82.49	I-Pentane	= .030
Ethane	= 6.220	N-Pentane	= .030
Propane	= 1.320	N-Hexane	= .020

The compressor efficiency function requires 10 channels to complete its calculations. This example uses channel addresses 801 to 810. Assign function code 175 to channel address 801 and the system automatically reserves channel addresses 802 to 810.

Once a block of 10 channel addresses is reserved, simply enter the constants required to complete the calculation. Table 4 lists the specific channel parameters where the constants are entered; the values to be programmed are written in italics. Because we are using constants, not calculated values, to compute the compressor efficiency, the address of the data does not have to be entered at the source parameter. Enter a value of 000 for Source 1 and assign the constant to Input 1. Likewise, enter a value of 000 for Source 2 and assign the constant to Input 2. If Digi 4 calculates a value, e.g., inlet pressure, assign the channel address where the data is calculated to the source parameter.

Figure 1 is a Digi 4 program listing which displays the constants programmed at channel addresses 801 to 810. The constants appear in the Input 1 (IN1) and Input 2 (IN2) columns. The values that appear in the Output 1 (OUT1) and Output 2 (OUT2) columns reflect intermediate calculations which the compressor efficiency function uses to complete its computations. The user does not program values at these parameters.

In addition to the isentropic compression efficiency, the compressor efficiency function also calculates:

- The actual work done on each pound of the gas
- The molecular weight of the mixture
- The molal density and compressibility of the inlet state
- The molal density and compressibility of the outlet state
- The molal density and compressibility of a base state
- The specific gravity of the mixture at the base state

Each channel displays a different calculated value. Table 4 lists the output data at each channel address. The output data is function, not source, related. That is, the output data at each channel address is calculated based on all of the input data, not just the input data at the channel address where it is displayed.

Figure 2 is a Digi 4 report which displays the output data at Channel Addresses 801 to 810. The calculations are based on the constants given on the previous page. We suggest that you use the same constants to set up the compressor efficiency function and verify that the output data matches that in figure 2. Then you can change the constants to match your actual data or enter the address where you are measuring the value. For example, if you are measuring the inlet pressure at Channel Address 103, assign 103 to Source 1 at Channel Address 801.

Table 4. Application Example

Channel Address	Function/ Decimal	Source 1*	Source 2**	Channel Output Data
801	175 *0.0*	Inlet Pressure (P_1) in psia *516.10*	Mol% CO_2 *.100*	Value of Isentropic Compression Efficiency (EFFIC)
802	201 *0.*	Inlet Temperature (T_1) Degrees F *36.00*	Mol% Nitrogen *9.470*	Work done on each pound of the gas, in Ft-lbf/lbm. (WA)
803	202 *0.000*	Exit Pressure (P_2) in psia *812.5*	Mol% Methane *82.49*	Molecular weight of the mixture in lbm/lb-mol. (M)
804	203 *0.000*	Exit Temperature (T_2) Degrees F *113.30*	Mol% Ethane *6.220*	Molal density of inlet state in Ft^3/lb-mol (D_1)
805	204 *0.000*	Base Pressure (P_b) in psia *14.730*	Mol% Propane *1.320*	Compressibility factor of inlet state (Z_1)
806	205 *0.000*	Base Temperature (T_b) Degrees F *60.00*	Mol% i-Butane *.110*	Molal density of exit state in Ft^3/lb-mol (D_2)
807	206 *0.000*	Specific volume of air at base conditions, in Ft^3/lbm (V_{ab} Ft^3/lb) *13.063*	Mol% n-Butane *.210*	Compressibility factor of exit state (Z_2)
808	207 *0.000*	Specific heat at constant pressure, in BTU/lb-Mol/R (C_{po} Btu/lb-mol-R) 8.0 BTU/lb-mol/°R is default value. *8.0*	Mol% i-Pentane *.030*	Molal density of base state, in Ft^3/lb-mol (D_b)
809	208 *0.000*	---	Mol% n-Pentane *.030*	Compressibility factor of base state (Z_b)
810	209 *0.000*	---	Mol% n-Hexane *.020*	Specific gravity of mixture at base state (G_b)

* Enter a value of 000 for Source 1 and assign the constant to Input 1.
** Enter a value of 000 for Source 2 and assign the constant to Input 2.

CHANNEL PARAMETERS 09 05 84 15:15:22

CHN	LABEL	FN	DECIMAL	SOURCES	IN1	IN2	OUT1	OUT2	UNITS	LIM1	TYP	OP1	OP2	OP3	LIM2	TYP	OP1	OP2	OP3
801	EFFIC	175	0.0	000 000	516.10	0.100	.....	4304.8		.....	H	000000	000000	000000	.....	H	000000	000000	000000
802	WA	201	0.	000 000	36.000	9.470	-59365.	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
803	M	202	0.000	000 000	812.5	82.49	-43891.	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
804	D1	203	0.000	000 000	113.30	6.220	5.6058	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
805	Z1	204	0.000	000 000	14.730	1.320	.....	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
806	D2	205	0.000	000 000	60.000	0.110	-5664.2	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
807	Z2	206	0.000	000 000	13.063	0.210	-40392	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
808	DB	207	0.000	000 000	8.0	0.030	.....	6033.4		.....	H	000000	000000	000000	.....	H	000000	000000	000000
809	ZB	208	0.000	000 000	.....	0.030	38153.	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000
810	GB	209	0.000	000 000	.....	0.020	.....	.....		.....	H	000000	000000	000000	.....	H	000000	000000	000000

Figure 1. Program Listing of Compressor Efficiency Function

09/05/84 15:14:09

801	802	803	804	805	806	807	808	809	810
EFFIC	WA	M	D1	Z1	D2	Z2	DB	ZB	GB
68.1	26327.	18.629	0.107	0.908	0.144	0.919	0.003	0.998	0.644

Figure 2. Data Output by Compressor Efficiency Function

REFERENCES

1. "Documentation of the Benedict-Webb-Rubin Mark 2 Program", J.B. Anderson, American Gas Association Transmission Conference, San Francisco, CA, May 1972.

2. "CRC Handbook of Chemistry and Physics", 63rd Edition, CRC Press, Inc., Boca Raton, FL, 1982.

APPENDIX A

Table A. Universal Gas Constant In Several Units And Specific Gas Constants For A Number Of Gases.

Pressure	Units	lbf/in^2	lbf/ft^2	Atm	Kgf/m^2	$Newt/cm^2$	Atm
Temperature	Units	R	R	R	K	K	K
Volume	Units	ft^3/lbm	ft^3/lbm	ft^3/lbm	m^3/Kgm	cm^3/gm	cm^3/gm
Universal Gas Constant	Value	10.7315	1545.34	0.730233	847.970	831.574	82.0700
	Units	$\frac{lbf\text{-}ft^3}{in^2\text{-}mol\text{-}R}$	$\frac{lbf\text{-}ft}{mol\text{-}R}$	$\frac{Atm\text{-}ft^3}{mol\text{-}R}$	$\frac{Kgf\text{-}m}{mol\text{-}K}$	$\frac{Newt\text{-}cm}{mol\text{-}K}$	$\frac{Atm\text{-}cm^3}{mol\text{-}K}$

Specific Gas Constants - Units are in Header

Gas	Molecular Weight	$\frac{lbf\text{-}ft^3}{in^2\text{-}lbm\text{-}R}$	$\frac{lbf\text{-}ft}{lbm\text{-}R}$	$\frac{Atm\text{-}ft^3}{lbm\text{-}R}$	$\frac{Kgf\text{-}m}{Kgm\text{-}K}$	$\frac{Newt\text{-}cm}{gm\text{-}K}$	$\frac{Atm\text{-}cm^3}{gm\text{-}K}$
Air	28.9644	0.370507	53.3531	0.0252114	29.2763	28.7102	2.83348
NH_3	17.0306	0.630130	90.7390	0.042777	49.7910	48.8282	4.81897
CO	28.0106	0.383123	55.1698	0.026070	30.2732	29.6878	2.92996
CO_2	44.0100	0.243842	35.1134	0.016592	19.2677	18.8951	1.86480
H_2	2.0159	5.3234	766.58	0.36224	420.64	412.51	40.7113
N_2	28.0134	0.38310	55.1643	0.026067	30.2702	29.6849	2.92967
O_2	31.9988	0.33537	48.2937	0.02282	26.5001	25.9877	2.56478
SO_2	64.07	0.16750	24.1196	0.011397	13.2350	12.9791	1.28094
Methane	16.0430	0.66892	96.3248	0.045517	52.8561	51.8341	5.11563
Ethane	30.0701	0.35688	51.3912	0.024284	28.1998	27.6545	2.72929
Propane	44.0972	0.24336	35.0439	0.016560	19.2296	18.8578	1.86112
Butane	58.1243	0.18463	26.5868	0.012563	14.5889	14.3068	1.41197
Pentane	72.1513	0.14814	21.4180	0.010121	11.7527	11.5254	1.13747
Hexane	86.1782	0.12453	17.9319	0.008474	9.8397	9.6495	0.95233
Xylene	28.0542	0.38253	55.0841	0.026029	30.2261	29.6417	2.92541